REPORT RESUMES

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REORGANIZED SCIENCE CURRICULUM, 9, NINTH GRADE SUPPLEMENT.
MINNEAPOLIS SPECIAL SCHOOL DISTRICT NO. 1, MINN.
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THE FIFTEENTH IN A SERIES OF 17 VOLUMES, THIS VOLUME PROVIDES THE NINTH GRADE TEACHER WITH A GUIDE TO THE REORGANIZED SCIENCE CURRICULUM OF THE MENNEAPOLIS PUBLIC SCHOOLS. THE MATERIALS ARE INTENDED TO BE AUGMENTED AND REVISED AS THE NEED ARISES. THERE IS A BRIEF SUMMARY OF SUBJECT MATTER CONTENT FOR GRADE 9, AND A CHART OF GRADE CONTENT ASSIGNMENTS FOR THE ENTIRE K-12 PROGRAM IN EACH OF THE FOLLOWING MAJOR AREAS AROUND WHICH THE PROGRAM IS DESIGNED--(1) THE EARTH, (2) LIVING THINGS, (3) ENERGY, AND (4) THE UNIVERSE. THIS VOLUME ALSO CONTAINS THESE SECTIONS--(1) CONCEPTS, (2) LEARNING EXPERIENCES, (3) BIBLIOGRAPHY, BOOKS, (4) BIBLIOGRAPHY, FILMS, (5) BIBLIOGRAPHY, FILMSTRIPS, AND (6) EQUIPMENT AND SUPPLIES. THE LEARNING EXPERIENCES SECTION EMPHASIZES REGULARITIES IN THE WEIGHTS OF COINS, AND A SCIENTIFIC ATTITUDES CHECKLIST. (DH)

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SCIENTIFIC APPROACH TO PROBLEM SOLVING

1. Observation--first-hand experiences and observation.

2. Definition of PROBLEM--ask questions, choose one for investigation.

3. Results of other investigators--read about problem, discuss it with interested friends and resource people, examine the written material.

4. Possible solutions--list all possible guesses.

5. Choosing the best solution (HYPOTHESIS)--pick the "best guess".

6. Testing the hypothesis--planning and carrying out EXPERIMENTS to determine its truth.

7. CONCLUSION of accepting or rejecting hypothesis--draw conclusion from experiments to determine acceptance or rejection of "best guess".

8. More extensive testing of hypothesis--experiment further to determine if hypothesis always holds true.

9. Stating the THEORY and publishing results--restate the hypothesis in light of the above experimentation, publish in professional journal.

10. Finding mathematical proof--do any measuring and mathematical calculations to develop proof of theory.

11. Statement of LAW or PRINCIPLE--if no one can find a mistake in the mathematical proof or develop a contrary proof, the theory becomes a law or principle.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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THE GRADE NINE SUPPLEMENT

to the

REORGANIZED SCIENCE CURRICULUM

Kindergarten Through Grade Twelve

(For Discussion Purposes Only)

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MINNEAPOLIS PUBLIC SCHOOLS
special school district no. 1
Minneapolis, Minnesota

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MINNEAPOLIS PUBLIC SCHOOLS
special school district no. 1
Minneapolis, Minnesota

October 21, 1966

FOREWORD

Long before that famous October fourth, 1957, when Sputnik I rocketed into orbit, the science teachers of the Minneapolis Public Schools eagerly began work on the reorganization of the science curriculum from kindergarten through grade twelve. This reorganized science curriculum was requested by our instructional staff and developed by representative members of that staff.

The citizen of today must be science literate in order to exercise adequately his duties of citizenship. The contribution of the scientist to our way of life is the methods which he uses to attack a problem and seek its solution. These methods are unique, but more important, they are very useful; they can be applied in the solution of the everyday problem by knowledgeable children at all ages and grade levels, and by adults in all walks of life. If these methods of science are to be learned by the youth of Minneapolis, they must be learned by attacking realistic problems inside and outside the classroom. This practice in the solving of work-a-day problems trains our young citizens to think for themselves in seeking new solutions to age-old problems of our civilization.

In the Minneapolis Public Schools we recognize that science is a very important part of the liberal arts general education which should be studied by all students. We are aware of our responsibility for instruction which must be well grounded in the fundamental laws and principles in all the fields of the basic sciences and therefore propose this reorganized curriculum for teaching the ever-expanding knowledge of science.

This reorganized science curriculum does not teach itself. It is a planned developmental approach in which the teacher is the expeditor and not the limiter of learning. The curriculum has been developed to aid the student in acquiring new breadths and new depths of understanding of his environment; and with it a teacher who is well trained in science may lead the student in an ever-expanding investigation of his surroundings in this world and universe. If the curriculum is used cooperatively by teacher and students, it is an instrument which can mold a pupil of the Minneapolis Public Schools into a science-literate citizen who, if he continues advanced science training, may become a scientist of the future.

Rufus A. Putnam
Superintendent of Schools

INTRODUCTION

This Supplement has been prepared as a convenient reference to assist the ninth grade general science teacher to produce an effective program of instruction with his pupils. General science teachers suggested the content and assisted with the preparation of each section of this Supplement. Those who helped prepare this material laid no claim to its "perfection". However, its value to each and every ninth grade science teacher can only be determined by its use and subsequent constructive suggestions made for its improvement. All Minneapolis Public Schools personnel are invited to cooperate in the updating and improvement of this Supplement as a usable academic tool for the beginning and experienced classroom science teacher.

This Supplement is not complete at the present time. When additional useful materials are developed, a copy will be furnished to you to place in these loose-leaf binders. Your cooperation with us to keep your Supplement up-to-date will be appreciated. When you leave our Minneapolis Public Schools, please leave your Supplement in your room for the next teacher's use.

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

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purposes only

SUMMARY OF GRADE-CONTENT ASSIGNMENTS

Area and Major Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12
Introduction to Science (Gray)	*	*	*	+	*	*	*	+	+	+	+	+	+
A. Attitudes (Including history)	+	+	+	+	+	+	+	+		+			+
B. Tools	+		+	+	+		+		*				+
C. Methods	+		+	*	+	+	+			*			
I. The Earth (Red)	+	+	+	*	*	+		+	*				
A. History of the earth					+				+				
B. Physical features	*	+		+	+				+				
C. Rocks and minerals	+	*			+				+				
D. Soils		+		+	+				+				
E. Water	*		*	+	*			*					
F. Air	+	*		+	*			*					
G. Weather and climate				+		*			*				

Key to symbols -- * major emphasis
+ content to be taught

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Area and Major Topics	Grade Level												
	K	1	2	3	4	5	6	7	8	9	10	11	12
II. Living Things (Green)	+	+	+	+	+	+		*			*		
A. Life and life processes	+	+	+	+		*		+			+		
1. Life in general	+			*		+		+			+		
2. Food taking or nutrition		*	*	+		+		+			+		
3. Digestion								+			+		
4. Absorption						+		+			+		
5. Circulation				+		+		+			+		
6. Respiration						+		+			+		
7. Assimilation								+			+		
8. Oxidation						+		+			+		
9. Excretion				+		+		+			+		
10. Reproduction and growth		*	*	*		+		+			+		
11. Responsiveness	+	*	+	+		+		+			+		
B. Classification	*	+	+	+		*		+			+		
C. Ecology	*	+	*	*	*			+			+		
D. Plant and animal economics	+	+	+	*	*			+			+		
E. Human body	*	*	*	*		*		*			+		
F. Aesthetic values	*			*				+			+		

(continued)

Grade-content assignments (continued)

Area and Major Topics	Grade Level											
	K	1	2	3	4	5	6	7	8	9	10	11
III. Energy (Yellow)	+	+	+	+	+	+	+			+		*
A. Properties of matter related to energy	+			*			*			*		+
B. Sources and conservation of energy	+			+		*				+		+
C. Mechanical energy and simple machines	*		*	*			*			*		+
D. Gravitational energy	+			+			+			+		+
E. Magnetic energy	*		*	+	*					+		+
F. Sound		*	*				*			+		+
G. Electrical energy		*		*		*				*		*
1. Static						+				+		+
2. Current		*		*		+				*		+
H. Communication bands and electronics												+
I. Heat and infrared radiation	*			*		*				+		+
J. Light and ultraviolet radiation	*	*	*				*			+		+
K. High energy waves												+
L. Chemical energy				+			*			*		
M. Atomic energy							+			+		+

For discussion purposes only

Area and Major Topics	Grade Level												
	K	1	2	3	4	5	6	7	8	9	10	11	12
IV. The Universe (Blue)	+	+	+	+		*	+		*	+			
A. Earth	+	*	*	*		+			+				
B. Moon	*		*			+			+				
C. Sun	*	*	*	*		+			+				
D. Solar system						+			+				
E. Stars and galaxies	*		*	*		+			+				
F. Space travel		+	+	+			*			*			

Key to symbols - - * major emphasis

+ content to be taught

Note: Conservation and safety must permeate science teaching at all grade levels.

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5-27-63

CONCEPTS

A SUMMARY OF THE SUBJECT MATTER CONTENT

GRADE NINE

Introduction to science--some steps in solving scientific problems; growth of science knowledge

Energy from matter--physical properties of matter; mixtures, including solutions; chemical elements, compounds, molecules, and ions; acids, bases, and salts; chemical change

Energy, force and motion--work and power; kinds, efficiency, and mechanical advantage of machines; forces creating or affecting motion in matter; potential and kinetic energy; gravity

Electrical energy--properties of charged particles; measurement and control of flow of electricity; magnetic fields; permeability and retentivity of magnetic materials; relation between strength of an electromagnet and an electric current

Common forms of wave energy--sources; measurement, reflection and refraction of light; light detecting devices; transfer and control of heat; difference between temperature and heat content; temperature scales and their characteristics; pitch, intensity, quality and reflection of sound; methods of making sounds with musical instruments

Nuclear structure and sources of energy--structure of the atom; fission and fusion; potential and kinetic energy

Aerospace--(review of most of the concepts included in all other junior high school units) lift, thrust and drag due to airfoils; characteristics of space; orbital and escape velocities; navigation, control, guidance and communication in space vehicles

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Grade Nine

ALLOCATION OF CONCEPTS BY MAJOR TOPICS AND/OR UNITS

TABLE OF CONTENTS

Major Topic and/or Unit — Page Number — Color

Introduction to Science

A. Methods of science.................. 1 Gray
B. Characteristics of creative scientific work..................... 2 Gray
C. Economic values of science......... 2 Gray

III. Energy--Energy from matter

A. Properties of matter related to energy............................. 3 Yellow
B. Chemical energy..................... 7 Yellow
III. Energy--Sources and conservation of energy................................. 10 Yellow

III. Energy--Energy, force and motion

A. Energy, work, power................ 11 Yellow
B. Machines........................... 12 Yellow
C. Friction........................... 13 Yellow
D. Engines............................ 14 Yellow
E. Physics of gases and liquids....... 15 Yellow
F. Force and motion................... 15 Yellow
G. Gravity............................ 16 Yellow

III. Energy

A. Magnetic energy.................... 17 Yellow
B. Earth's magnetism.................. 19 Yellow

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Major Topic and/or Unit — Page Number — Color

III. Energy--Electrical energy

A. Static electricity.................. 19 Yellow
B. Current electricity.................. 20 Yellow

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Nature of light..................... 22 Yellow
Photometry.......................... 23 Yellow
Reflection and refraction.......... 23 Yellow
Optical instruments................ 24 Yellow
Eye................................. 25 Yellow
Color............................... 25 Yellow
Ultraviolet radiation.............. 26 Yellow

B. Heat and infrared radiation

Sources of heat energy............. 26 Yellow
Methods of heat transfer........... 27 Yellow
Effects of heat.................... 28 Yellow
Change of state.................... 29 Yellow
Measurement of heat................ 29 Yellow
Cause of weather................... 31 Yellow
C. Sound............................ 32 Yellow

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Major Topic and/or Unit — Page Number — Color

III. Energy--Atomic structure and nuclear energy

A. Nature of the atom................. 34 Yellow

B. Fission............................ 36 Yellow

C. Fusion............................. 38 Yellow

Aerospace--A summary unit

Delineation of content................. 39 Blue

A. Air, aircraft, aviation

Lighter than air craft............. 40 Blue

Aircraft in flight................. 41 Blue

B. Introduction to space travel....... 42 Blue

C. Navigation and guidance in space travel............................. 43 Blue

D. Communication in space travel...... 44 Blue

E. Biological and physical problems in space travel...................... 44 Blue

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Grade Nine

ALLOCATION OF CONCEPTS BY MAJOR TOPICS AND/OR UNITS

Note: This report presents a list of unit titles or major topics within which the order of the concepts found in the Handbook has been changed and grouped under subheadings to provide a logical teaching approach.

Introduction to Science

A. Methods of science

1. Future scientific investigation should begin with a critical review of the known scientific principles.
2. Studies in basic science start with scientific principles investigated in the past.
3. Time-lapse experiments require continuous and/or multiple periodic observations before a valid conclusion may be drawn.
4. Scientists begin the solution of a problem by recognizing that a problem exists.
5. Scientific techniques and methods should be critically reviewed as an investigation proceeds.
6. A scientist tries to control all the variables in an experiment except one.
7. The combined use of qualitative and quantitative approaches is necessary in seeking the solution of scientific problems.
8. A reasoned explanation for a certain phenomenon which is based on experimental fact is very often called a theory.
9. A scientist publishes observations and conclusions.
10. Scientists should continually re-evaluate conclusions.
11. A scientist compares his conclusions with those of other scientists.
12. Every new scientific investigation suggests problems for future investigation.

B. Characteristics of creative scientific work

1. Creative scientific work grows out of experiences and projects initiated by individuals or groups.
2. Modern scientists have extended man's understanding of the complex laws of nature.
3. Scientific theories can only become laws or principles if they can be proved mathematically.
4. Scientific progress usually requires effort.
5. Greater understanding of the cause and effect relationships in our environment is acquired by an expansion of investigations.
6. Knowledge derived from scientific study may be the basis for further investigation.
7. Many research teams work on problems in basic science.

C. Economic values of science

1. Experimental science developed very slowly before the nineteenth century.
2. During the twentieth century the rate of acquiring scientific knowledge has been accelerating rapidly.
3. Through the accurate observations, calculations, and conclusions of the early scientists, groups of laws and principles were developed.
4. Contemporary scientists usually work in research teams on highly specialized problems in specific fields of science.
5. Modern research teams usually center their investigations on basic or applied research.

III. Energy--Energy from matter

A. Properties of matter related to energy

1. In science, theories are proposed which may explain the properties or behavior of matter and/or energy.

2. Regardless of the amount of mixing, two portions of matter cannot occupy the same space at the same time.

3. The mass of a substance is a measurable quantity.

4. The mass of a given quantity of material is usually expressed in weight units.

5. The mass of a substance is usually expressed as weight, even though actually weight is a measure of gravitational attraction.

6. Mass is determined by comparison with a standard mass.

7. The mass of a substance is usually expressed as a comparison with another substance which is arbitrarily assigned a definite mass.

8. Mass is a constant quantity under normal conditions.

9. Weight is a variable quantity.

10. The weight of a substance is determined by its mass and the gravitational force acting on it.

11. Weight is the product of the mass and the gravitational attraction.

12. The volume of a solid of an irregular shape is usually found by an indirect method.

13. Volumes of solids which are regular in shape can be determined directly by measurement of their linear dimensions and by using the tool of mathematics.

14. A floating object sinks until it displaces its own weight of a fluid.

15. Fluids exert a lifting force on masses in them.

16. A substance can be described in terms of its physical and chemical properties.

17. Substances vary in number and size of pores (porosity).

18. Most properties of substances can be explained if it is assumed that all matter is made up of extremely small particles in constant motion.

19. The molecules in a solid could be considered to be vibrating in position, unable to pass around one another as they usually do in fluids.

20. Solids are of two general types, crystalline and amorphous.

21. Solids may exist in the form of crystals.

22. The particles in a solid may be considered to be arranged in an orderly fashion while those in fluids are disorderly.

23. Crystalline substances have a characteristic arrangement of atoms, molecules, or ions.

24. Many crystalline solids may be partially identified by the shape of their crystals.

25. If liquids are cooled suddenly, a solid may form which does not have an ordered pattern of arrangement of atoms, molecules or ions.

26. The surfaces of solid substances vary in hardness.

27. Solid substances vary in ability to rebound after collision.

28. The amount of rebound may nearly equal the amount of impact.

29. All solids and liquids have a bounding surface.

30. All objects resist distortion.

31. A distorted object tends to return to its original shape.

32. Solid substances vary in ability to bend and return to the original shape (flexibility).

33. Shapes and a few other physical characteristics of some substances may be changed by mechanical force.

34. Some solid substances may be hammered or pressed into thin sheets.

35. Friction between molecules of a fluid is called viscosity.

36. Unbalanced intermolecular attractive forces between molecules in some liquids at any interphase causes the liquid to seem to have a "skin".

37. In capillarity the size of the bore of a tube, and the composition of both the liquid and the tube determine the height to which the liquid rises.

38. Under certain conditions, a liquid rises in a tube above its existing level or is depressed below it.

39. Some characteristics of a material may be modified without changing the original material to a new material.

40. All matter exists in one of the three different states at ordinary conditions.

41. Most substances may exist in three states.

42. As heat is added to a substance, the molecular motion increases.

43. The state of matter is dependent in part upon the motion of its molecules.

44. A pressure change may affect the freezing points and boiling points of substances.

45. The boiling point of a substance is a function of the pressure.

46. The amount of heat necessary to raise the temperature of a substance varies with the size of the object.

47. It takes different amounts of heat to raise the temperature of different quantities of the same substance through the same temperature range.

48. In two different quantities of the same substance at the same temperature the amount of heat differs.

49. Changing a substance from one state to another requires the absorption or release of energy.

50. Usually materials assume any of three states of matter without a change in chemical composition.

51. In a physical change, there will be no change in the chemical composition of the substance.

52. Some materials, when heated, go immediately from a solid to a gaseous state without passing through a liquid state (sublimation).

53. Solid carbon dioxide is called "dry ice" because it has no natural liquid state.

54. Substances may be blended by mechanical means into mixtures which exhibit the aggregate characteristics, useful and detrimental, of the components.

55. Substances found in nature may be alike in some ways, but different in other ways.

56. Substances in nature are usually heterogeneous.

57. Two or more substances may be mixed so that the resultant substance may be considered homogeneous.

58. Some substances disperse themselves evenly throughout anothe substance.

59. Dissolving a substance is a physical change not a chemical change.

60. A solution contains particles of solute uniformly dispersed throughout the solvent.

61. The properties of water profoundly influence all life.

62. Water dissolves more substances than any other common solve

63. Although water is the most common solvent, all materials ar capable of acting as solvents.

64. The amount of solute which may be dissolved in a solvent varies with different substances and conditions.

65. Water is able to dissolve a greater number of different substances than any other solvent.

66. The rate of dissolving and amount of solute which may be dissolved in a solvent depends upon numerous physical characteristics of the components and the conditions of the environment.

67. There is a maximum amount of a substance that can dissolve in a given amount of water at a given temperature.

68. Certain conditions may enable solutions to contain more tha the predicted ratio of solute to solvent (supersaturatio

69. The separation of a solution into its components may be accomplished by various methods involving use of several physical and chemical properties of matter.

70. Some substances with suitable properties may be separated by distillation.

71. Some aggregates or mixtures may be separated into component by certain physical methods.

72. Substances may be separated from other substances by utilizing differences in their properties.

73. Some solid substances have other substances dispersed throughout them.

74. The physical properties of water may be utilized in various ways.

75. The chemical and physical properties of impurities in water may be utilized to remove them.

76. Consecutive vaporization and condensation (distillation) are often used to separate (purify) materials.

77. Some particles are too big to go into solution but too small to settle.

78. Common English and metric units of measurement of length, weight, volume and degrees are used to compute units of energy.

79. Quantities (amounts) of energy are measured in various kinds of units.

80. Instruments have been developed for detection and measurement of amounts of various kinds of energy.

81. Convenient new units of energy and work are derived from basic units of force and length.

B. Chemical energy

1. Every substance has characteristic chemical and physical properties.

2. Many substances may be identified by careful observation.

3. Chemical technology is the application of chemical principles.

4. All known matter in the universe is composed of the same elements found in the sun.

5. Only a few of the elements found in the earth's crust are abundant.

6. Each element is given a characteristic symbol.

7. Chemical symbols are used for convenience in writing equations.

8. Chemical symbols are accepted internationally.

9. Elements with similar characteristics have similar properties.

10. The elements may be sorted into several natural groups.

11. Sorting and/or grouping materials according to differences and similarities helps to learn more about them.

12. Metals are often differentiated from nonmetals by chemical properties.

13. Chemical formulas tell the elements which are combined to form a compound.

14. A molecule is the smallest particle of a substance which has the properties of that substance.

15. All the molecules of a given substance are alike, but the molecules of one substance are different from the molecules of every other substance.

16. Two or more atoms bonded together form a molecule.

17. A molecule may be formed of one kind of atom or many different kinds of atoms.

18. Compounds are composed of two or more atoms of two or more elements.

19. Elements unite in definite proportions to form compounds.

20. The combining capacity of atoms, called valence for convenience, enables chemists to express the significance of definite proportions.

21. In most chemical changes two or more substances react with each other.

22. The substances formed by chemical change may have properties which are more useful than the original substances.

23. Chemists attempt to make new substances whose properties are more useful than known substances.

24. New compounds and new uses for known compounds are continually being discovered.

25. Often more than one method may be used to obtain the same chemical substance.

26. Water may be purified by numerous means.

27. Certain chemical reactions can produce a flow of electrons.

28. The flow of electricity through solutions of certain compounds can produce chemical changes.

29. An ion has an excess or deficiency of electrons.

30. An ion is a positively or negatively charged particle.

31. An ion is a charged atom or group of atoms.

32. An acid has an excess of hydrogen ions in solution.

33. An acid may be considered as a substance which produces hydrogen ions in water solutions.

34. An acid has a sour taste,

35. A base has an excess of hydroxyl ions in water solution.

36. A base has a bitter taste and a slippery feeling.

37. Bases and acids have several physical properties which may be utilized under some conditions for identification purposes.

38. A crystalline compound that consists of a positive ion other than hydrogen and a negative ion other than hydroxyl is an inorganic salt.

39. Acids, bases, or salts may be identified by tests.

40. Various "indicators" may be utilized for determination of properties of substances.

41. In a chemical change new substances are formed which are chemically different from the original substances.

42. Practically all transformations of matter other than changes of state involve simultaneous chemical changes.

43. When a new material is made, some substance has undergone chemical change.

44. Chemical changes may be useful or detrimental.

45. Sometimes when solutions are mixed, no change may be observed.

46. Chemical changes may change useful substances into less useful materials.

47. Chemical reactions are either endothermic or exothermic.

48. Heat may cause a substance to decompose into simpler substances.

49. Mixtures of some substances react chemically only if energy is added to start the reaction.

50. Many chemical reactions continue after a small amount of energy is added to start the reaction.

51. A flame is a burning gas.

52. When materials burn, they are oxidized and produce heat and light.

53. Combustion of fuels releases heat and forms by-products.

54. Mechanical energy may be produced indirectly from chemical energy.

55. When a gas is the product of a chemical reaction, the force of expansion may be used to do work.

56. Chemical reactions may produce harmful products or dangerous quantities of energy.

57. In the most general terms organic substances are formed by and are a part of living things while inorganic substances have never been part of a living thing.

58. Organic compounds are compounds which always contain carbon.

59. Certain chemical processes and reactions common to living things may be duplicated artificially.

60. Light can cause a chemical change in certain substances.

61. Photosynthesis produces the chemical energy of food which living things utilize.

62. Blueprints and photography depend on chemical changes which are induced by light energy.

III. Energy--Sources and conservation of energy

1. Energy is the ability and capacity to do work.

2. Food energy may be released by the process of oxidation.

3. Matter is a form of energy.

4. Matter cannot be easily destroyed.

5. Energy may neither be created nor destroyed, but a great deal is lost to man's use each day.

6. Most of our energy comes from the nuclear energy of the sun.

7. Forms of energy which radiate in all directions from a point source are called radiant energy.

8. The energy which the earth receives from the sun is produced by nuclear fission and fusion.

9. Nuclear reactions produce various forms of energy.

10. Tremendous quantities of energy are produced during nuclear fusion and fission in the sun.

11. Atomic energy is produced by nuclear fission or fusion.

12. Potential energy is usually possessed by a mass at rest.

13. Potential energy is the energy an object has because of its position or natural condition.

14. Kinetic energy is the energy of motion.

15. Energy can neither be created nor destroyed; it can be changed from one form to another.

16. Kinetic energy may be converted into potential energy.

17. Potential energy may be converted into kinetic energy.

18. Potential energy is changed into kinetic energy in many machines and devices.

19. Some machines change kinetic energy to potential energy which very often cannot be used.

20. Within the power plant of an aircraft the potential energy of the fuel is converted into kinetic energy.

21. Proper maintenance of equipment contributes to conservation of material.

III. Energy--Energy, force and motion

A. Energy, work, power

1. Energy must be expended to get things done.

2. In measuring the quantities of energy delivered the rate of delivery is measured in an amount per unit of time.

3. Objects moving in any direction can do work.

4. Work is the result of moving an object in the direction of the applied force.

5. The amount of push or pull on an object can be measured (force).

6. No matter how hard you push or pull against a substance, no work is accomplished until it moves in the direction of the push or pull.

7. Work is the product of the force and the distance it moves in the direction of the applied force.

8. Power is the ratio of work to time.

9. Power is a quantity with magnitude but not direction.

10. When the amount of work done in a given amount of time is measured or calculated the quantity of power may be determined.

11. The mechanical unit for power in the English system is the horsepower; in the metric system it is the watt.

12. Force and/or power can be transmitted through machines.

III. Energy--energy, force and motion

B. Machines

1. To do work many machines employ the released forces of a compressed substance; e.g., caissons, jack hammers.

2. The functioning of many devices may be dependent upon the ever-present forces of nature; e.g., gravity, friction, earth's magnetism.

3. Many devices utilize the ever-present forces of nature to do work.

4. A machine may transfer energy from one place to another.

5. When a machine is used to do a specific amount of work, a greater, equal, or lesser force may be required.

6. When a machine is used to gain speed, there is a loss of force.

7. When a machine is used to gain force, there is a loss of speed.

8. Many machines are composites or modifications of specific simple machines.

9. In simple machines, the product of the force and the distance through which it is applied is related to the resistance and the distance through which it is moved.

10. The efficiency of a machine or device is the ratio of the amount of useful work output to the amount of work put into the machine or device.

11. The actual mechanical advantage of a machine is the ratio of the resistance to the effort.

12. The actual mechanical advantage of a machine is the number of times it multiplies the force.

13. In a machine the ratio of the distance through which the effort moves to the distance through which the resistance moves is equal to the theoretical mechanical advantage.

14. The three classes of levers depend upon the relative positions of the fulcrum, the resistance and the effort.

15. When levers are used, it is important to know the position of the fulcrum, the resistance, and the effort.

16. A larger wheel and smaller wheel, when fastened to the same axle, may be used as a "wheel and axle" machines.

17. A wheel and axle may be used to increase force or increase speed.

18. In using a simple wheel and axle, a turning effort (torque) exerted on the wheel produces a greater turning force (torque) on the axle.

19. In using a simple wheel and axle machine, a turning effort on the axle may produce great speed on the wheel.

20. The amount of work done in moving an object up an inclined plane is not less than if the resistance were lifted directly.

21. Combinations of gears may be used to change the speed of rotation in a complex machine.

22. In automobiles, the speed of the engine may be varied by the accelerator.

23. Many sets of meshing gears are included in the transmission and differential of automobiles.

24. The transmission and differential of automobiles furnish great variations in force, direction and speed to the drive wheels.

25. The ratio of the turns of the little gear to the large gear varies inversely to the number of teeth in the respective gears.

C. Friction

1. Moving things must overcome the tendency of friction to stop them.

2. The frictional forces between two surfaces may be varied by the addition of a different media between the surfaces.

3. Lubricated moving parts "float" on the lubricant.

4. Lubrication usually replaces solid friction with liquid friction (exception graphite).

5. Fluid friction is generally less than solid friction.

6. The force of friction may enable an object to change the speed and/or direction of motion (velocity).

7. Many devices employ the force of friction to change rectilinear motion into rotary motion.

8. The energy released when a substance undergoes a change of state may be used to operate many machines.

9. Expansion or contraction of matter caused by varying the temperature may be used to do work.

[illegible]

D. Engines

1. Mechanical devices use various methods (compression, spark plug) to ignite vaporized gas.

2. Some engines are able to change chemical energy into mechanical energy.

3. Some devices convert heat energy into mechanical energy.

4. Heat engines change energy of heat into useful mechanical energy.

5. In heat engines, a definite amount of heat is changed into mechanical energy.

6. In reciprocating engines the crankshaft and connecting rods change the "back and forth" motion into rotary motion.

7. Reciprocating motion may be transformed into rotary motion by means of a crankshaft.

8. Heat energy from atomic nuclear reactions may be changed

rgy.

III. Energy--energy, force and motion

E. Physics of gases and liquids

1. Objects more dense than air may be lifted by rising currents of air.

2. Pressure is the ratio of force to area.

3. The density of a gas varies with the pressure that is exerted on the gas.

4. Air pressure on a surface is caused by bombardment of air molecules.

5. At a given altitude abrupt differences in air pressure may exist.

6. Atmospheric pressure may be expressed in terms of lengths of columns of fluids.

7. Atmospheric pressure varies with the distance above sea level.

8. The prevailing winds on the surface of the earth are the result of many forces.

9. Localized currents of air may move in any direction or change directions in relation to the general movement of an air mass.

10. The lifting force of a fluid under confined conditions is related to the applied pressure.

F. Force and motion

1. Mechanical forces may produce motion.

2. Mechanical energy is energy that tends to produce motion.

3. The mechanical energy in a swinging pendulum is alternately changing from kinetic to potential and from potential to kinetic.

4. Forces which influence motion are not always obvious or apparent.

5. After an object is in motion, an opposing force must act in order to stop it.

6. The attraction of all objects for other objects may furnish usable motion in the form of objects falling due to gravity.

7. The measurable factors used in determining energy are mass and displacement.

8. Newton's Laws of Motion express that force is the product of mass and its acceleration.

9. Acceleration of matter is caused by unbalanced forces acting on it.

10. Acceleration is change in velocity divided by the change in time.

11. One cannot determine if he is at rest or in uniform without a fixed reference.

12. With regards to some point of reference, motion is a continuous change of position.

13. Many objects which are considered to be at rest are in reality in motion because they are a part of a system which is in motion (solar system).

14. An object in uniform motion tends to continue in motion in a straight line.

G. Gravity

1. Gravity is a mutual force between bodies which may produce or tend to produce motion.

2. Gravitational forces always attract.

3. Arbitrary units may be used as gravitational measures of work.

4. The force of gravity is usually measured in weight units.

5. A foot-pound is the gravitational measure of work in the English system.

6. The mass of an object is independent of the force of gravity.

7. The force of gravitational attraction of two objects is related to their masses.

8. Whether an object may be moved against gravity depends on the magnitude and direction of the applied forces.

9. The gravitational attraction between two objects varies with the distance between their centers of mass.

10. The point of rotation of an object is dependent on its center of mass.

11. The description of the acceleration of an object usually assumes the observer is at "rest", or unaccelerated.

12. The relative position of the observer (frame of reference) and observed object are important in describing acceleration.

13. Theoretically, the acceleration of a falling object is independent of its mass.

14. Theoretically, the acceleration of free falling objects is a constant.

15. Parachutes are used to decrease the speed of freely falling objects.

16. Parachutes reduce the maximum terminal velocity of the falling load.

17. The force of gravity may be overcome by many other forces (buoyancy, angular momentum, magnetism, electrostatic force).

18. Forces can be introduced to oppose gravity, to retard acceleration, or to reverse acceleration.

19. Gravity is the force that holds the molecules of the atmosphere to the earth's surface.

20. The earth's gravitational attraction affects the density of air.

III. Energy

A. Magnetic energy

1. An invisible field of force surrounds a magnet.

2. A magnetic field may be detected.

3. Strong magnetic fields cause magnetic materials to become magnetized.

4. There are definite, defined patterns of polar interaction.

5. In magnetizing a magnetic material the poles of each atom or molecule are arranged in the same direction resulting in north-seeking and south-seeking poles of the magnet.

6. Some substances may be used to concentrate the lines of force of a magnet.

7. All magnetic materials do not retain their magnetism when removed from a magnetic field.

8. The ability of a magnetic material to retain its magnetism when removed from a magnetic field is a measure of its retentivity.

9. Different magnetic materials retain their magnetism to differing degrees when removed from a magnetic field.

10. Magnetic materials vary in the ease with which magnetic lines of force can pass through them.

11. A measure of the ability of a magnetic material to concentrate the magnetic flux is permeability.

12. In order to conserve energy bar magnets should be stored by stacking unlike poles together or by using "keepers".

13. A soft iron "keeper" placed across the poles of a magnet preserves the energy in permanent magnets.

14. During storage the de-magnetization of permanent magnets ma be retarded by substances that are more permeable than air.

15. Permanent magnets are used to furnish magnetic field for th magnetos in many portable gasoline motors.

16. When a magnet is moved back and forth through a coil of wir an electric current is induced in the coil.

17. Magnets are used in many machines to convert other forms of energy to electrical energy.

18. Electromagnets change electrical energy into electromagneti mechanical energy.

19. Electromagnets may be used when controlled magnetic fields are needed.

20. The operation of all generators and transformers is dependent on electromagnetism.

21. The diaphragm on the telephone receiver is moved to produce sound by the action of an electromagnet receiving curren pulsations from the transmitter of another telephone.

B. Earth's magnetism

1. The magnetic poles of the earth are not geographically 180° apart.
2. A dip needle is a permanent magnet mounted on a horizontal axis.
3. At the magnetic equator of the earth, a dip needle remains in a horizontal position.
4. At the magnetic poles of the earth, the dip needle is in a vertical position.
5. Electromagnetic disturbances in a vicinity may cause magnetic compass errors.
6. Usually an angular difference exists between geographical north and magnetic north (variation).
7. The angle of compass variation or angle of declination from true north is related to the position of the observer on the earth and the variations of the lines of magnetic force from an ideal situation.
8. Magnetic variation or angle of declination of a compass varies with the magnetic field immediately surrounding it.

III. Energy--Electrical energy

A. Static electricity

1. Static electricity is an unbalanced stationary electrical charge.
2. Any object which has an excess or a deficiency of electrons is said to be "charged".
3. An electroscope may be used to detect electrical charges.
4. Electrostatic forces can repel or attract.
5. Charged particles attract or repel other charged particles in a systematic manner.
6. Electrical charges placed on small particles usually enables us to control the small particles.
7. A charged object brought near a conductor may induce an opposite charge in the near end and a like charge in the remote end of the conductor.

8. Two rain clouds may have the opposite charge which, when neutralized, form a streak of lightning between them.

9. Lightning arrestors are usually placed on telephone lines and electrical power lines so that giant surges, resulting from the discharge of a rain cloud into these communication lines, are grounded temporarily.

B. Current electricity

1. In a broad sense, current electricity may be referred to as the flow of a negative charge along a conductor.

2. One only observes the effects of electricity, and not electricity itself.

3. Most materials used in the construction of electrical devices may be classified as conductors, resistors or insulators according to their ability to transmit the flow of electrons.

4. Electricity may be regulated, depending on the amount needed, by use of switches, transformers, conductors, resistors, and insulators.

5. Convenient terms have been arbitrarily derived or defined in the study of electricity.

6. In studying electric currents, an analogy may be drawn between closed water circuits and closed electrical circuits.

7. Electric currents may flow in one direction (direct current) or may periodically reverse (alternating current).

8. In direct current, the electrons flow steadily in one direction.

9. The ampere is a unit of electric current strength or rate of flow.

10. Electrical pressure is electromotive force or volts.

11. The volt is a unit of electrical pressure.

12. The ohm is a unit of electrical resistance.

13. Resistance in a electrical conductor may be thought of as similar to mechanical friction in machines.

14. The amount or rate of flow of a charge may be determined by several factors.

15. Relationships between the various aspects of the flow of an electrical charge may be expressed in simple mathematical equations.

16. The current intensity in a closed circuit is the ratio of the electromotive force to the resistance.

17. The resistance in a closed circuit is the ratio of the electromotive force to the current's intensity.

18. In a closed circuit, the electromotive force is the product of the current intensity and resistance.

19. In most house lighting, all appliances must have the same voltage rating or requirement.

20. When new electrical appliances or devices are to be connected to a circuit, the voltage ratings must be equal.

21. The current and voltage requirements of various devices in circuits largely determine the type of circuit to be used.

22. The choice in methods of connecting chemical cells is largely determined by the functions and requirements of the circuit used.

23. Each method of connecting chemical cells in circuits (series or parallel) has advantages and disadvantages.

24. Chemical batteries, though a source of electrons, have internal resistance due to their construction.

25. The polarity of an electromagnet depends upon the direction of the flow of the electrons.

26. The strength of an electromagnet depends upon the product of the current intensity and number of turns in the coil(s).

27. Magnetism may be induced in some substances when surrounded by an electric current.

28. Most meters which are used to measure electric current depend on the magnetic effects of an electrical current.

29. Many electrical devices depend on the magnetic effects of an electric current to produce motion.

30. Some devices use magnetic, mechanical, or chemical energy to produce an electric current.

31. Magnets are used in many machines to convert mechanical energy to electrical energy.

32. Some devices produce an electric current by the rotation of a coil of electric wire within a magnetic field or by the rotation of a magnetic field within a coil of wire.

33. The quantity of electricity produced by a generator varies with the strength of the magnetic field and the rate of rotation.

34. Materials which resist the flow of an electric current may be used to produce heat and light.

35. Devices that depend on materials which may be heated to incandescence usually are designed to prevent combustion of the material.

36. Electrical energy may be converted into heat and/or light energy by resistance.

37. The conversion of electrical energy to other forms may be considered to be "effects of electric current".

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Nature of light

1. Light is generally considered to be a part of an electromagnetic spectrum by present-day theories.

2. No theory of light completely explains the behavior of light.

3. Light does not need a conducting medium.

4. The speed at which light travels through a vacuum is constant.

5. Except for sunlight, most of the light on the earth is artificial.

6. Most sources of artificial light make use of the principles of incandescence, phosphorescence, and/or fluorescence.

7. Objects, when heated to incandescence, give off visible light.

8. The "fuzziness" or sharpness of shadows depends on the size of the source of light.

9. The shadow cast by an opaque body may be very dark in the central region and fade out to indistinct edges.

10. Some materials undergo chemical changes when exposed to light.

11. Some substances may convert light energy into electrical energy.

12. Light may be concentrated by smooth, polished surfaces.

13. Rough, dark surfaces may diffuse light.

14. Lighting installations may be designed to provide diffused light.

15. Light may be diffused in many ways.

16. The earth's atmosphere and surfaces may diffuse the sun's rays.

17. Some substances may limit the transmission of light waves to only one plane.

18. A light filter may transmit restricted light wave bands, and absorb others.

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Photometry

1. Glowing platinum at a specific temperature in a special box of definite size is the standard for the measure of light illumination.

2. The unit for measuring illumination is the foot-candle.

3. Candle power is the rate at which light is emitted by a source.

4. Candle power is a measure of light intensity.

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Reflection and refraction

1. A substance may become visible if it emits or reflects light.

2. A mirror may produce images which appear to be behind the mirror.

3. The characteristics of the image formed by a mirror are dependent upon the curvature of the mirror and/or the distance the object is from the mirror.

4. The angle at which a ray of light is reflected depends upon the angle at which it encounters a surface.

5. In reflected light rays the angle of incidence equals the angle of reflection.

6. Refraction is the bending of radiation.

7. All light waves are not refracted equally by a given substance.

8. The amount of refraction is dependent upon the length of the light wave.

9. The earth's atmosphere may reflect or refract light.

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Optical instruments

1. Some optical elements can disperse light into a band of colors.

2. Optical elements may be combined in manifold ways to form various optical instruments.

3. Some optical elements cause light rays to meet or cross.

4. The size and relative distance of the object and image can be related in simple mathematical terms to the focal length of an optical element.

5. The sizes of the object and image are related to their respective distances from an optical element.

6. The sizes of the object and image are dependent upon the focal length of the optical elements.

7. The focal length of an optical element is dependent upon the radius of curvature.

8. The focal length of a lens is positive or negative, depending upon the direction of curvature.

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Eye

1. Different living things differ in their ability to detect radiant energy.
2. Only a restricted band of electromagnetic radiations is visible.
3. Only very restricted bands of the electromagnetic spectrum may be observed at one time or with one device.
4. Only a very few electromagnetic radiations stimulate the sense organs of sight.
5. Light waves produce changes when they are focused on the retina of the eye.
6. The orientation of the eye may limit its scope of vision.
7. If a light is intense, the eye may not bring the light into focus and the light source may not be clearly defined.
8. The structure of the eye may be imperfect in such a way as to distort or limit the perception of an observer.
9. The structure of the eye contains elements necessary to gather, limit, and converge light in such a way as to transmit an image to the brain by way of sensory nerves.
10. The color perceived may be dependent upon the wave lengths of light that combine to stimulate the nerve receptors in the eye.

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Color

1. The color of light may be described in terms of the frequency of the radiation.
2. White light may be produced by the combination of some color bands in definite proportions.
3. Light of any one color may be a combination of many wave lengths.

4. Primary colors are those colors that can be blended to produce the widest range of hues.

5. Colors can be produced by combining the primary colors (blue, red, and green) or by subtracting them from the white light.

Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Ultraviolet radiation

1. Ultraviolet radiation is invisible.

2. Ultraviolet radiations have wave lengths slightly shorter than visible light.

3. Ultraviolet radiation may be helpful or harmful to living material.

4. Some substances can convert ultraviolet to visible wave lengths.

5. Some electromagnetic waves other than those of visible light may be used in photography.

B. Heat and infrared radiation

Sources of heat energy

1. Infrared radiation is heat.

2. Infrared radiation is invisible.

3. Infrared waves, which have wavelengths slightly longer than visible light, produce heat.

4. The mechanical sources of heat are friction, percussion, compression.

5. Continued percussion of matter usually increases its heat energy.

6. Heat can be produced by the compression of matter.

7. Other forms of energy may be changed to heat energy.

8. Man obtains heat energy from the chemical energy in food.

9. All heat energy cannot be utilized.
10. Certain heat properties of some substances may be utilized for safety purposes.
11. Heat energy may be changed to other forms of energy.
12. Heat energy can be converted to mechanical energy.
13. To change heat units into mechanical energy units, constants are used in mathematical equations.
14. The amount of heat energy stored in fuels as chemical energy can be expressed in calories or British Thermal Units (B.T.U.).
15. The calorie is a unit of heat in the metric system, and the British Thermal Unit is a unit of heat in the English system.
16. The amount of heat energy stored in food in the form of chemical energy usually is expressed in calories or kilocalories.
17. Food calories really are kilocalories, or multiples of 1000 calories.

III. Energy--common forms of wave energy

B. Heat and infrared radiation

Methods of heat transfer

1. The rate of heat transfer may be speeded up by various means.
2. The ways by which heat transfer can be controlled make use of all the principles of heat transfer.
3. Transfer of heat by molecular collision is conduction.
4. Heat may be transferred by currents in fluids.
5. Currents which distribute heat through a fluid may be induced by mechanical means.
6. Fluids which are heated become less dense and rise; as fluids release heat, they become more dense and sink.
7. When heat change occurs, the differences in density within a fluid create natural currents which tend to distribute the heat evenly throughout the fluid.

8. Heat travels through space by radiation.

9. In radiation, heat travels in every direction from its source.

10. Heat is transferred from the sun by radiation.

11. Heat is continually being lost into space.

12. When heat is radiated from an object, the amount of radiation varies directly as the surface area.

13. Reflection of heat is the bouncing of heat waves off the surface of an object.

14. All other things being equal, different materials on the earth's surface absorb different amounts of heat from the sun.

15. Black objects heat up more rapidly than white objects.

16. The reflecting and absorbing surface properties of an object may greatly influence the temperature of the object.

17. Economical ways by which heat loss can be reduced utilize insulators and reflectors.

18. Materials vary in their ability to absorb and retain heat.

19. When a metal is oxidized its surface characteristics may be changed and the ability to absorb or radiate heat may change.

20. In a few cases oxidizing a metal may greatly increase the ability to absorb heat.

21. In some cases when a metal is oxidized it becomes a good radiator and poor reflector.

22. Surfaces of objects may be changed by chemical reactions becoming surfaces with undesirable heat-reflecting and/or heat-absorbing qualities.

III. Energy--common forms of wave energy

B. Heat and infrared radiations

Effects of heat

1. When pressure is constant, most substances expand when heated and contract when cooled.

2. Alternate heating and cooling of a solid creates stresses which weaken the material.
3. Water may freeze in small imperfections on the surface of a solid and may eventually crack the solid.
4. Many mechanical heat measuring and controlling devices depend on the expansion of a material.
5. Temperatures may be determined by measurement of the amount of expansion or contraction of many substances.

Changes of state

1. Heat must be added or removed to change a substance from one state to another.
2. A change of state may occur between solids and liquids, solids and gases, or liquids and gases.
3. As a matter is converted from one form to another, energy is very often released or absorbed.
4. Moisture evaporates more quickly in dry air producing a cooling effect on the substance losing moisture.
5. The rate of evaporation increases with a temperature increase.
6. Refrigeration is a cooling process based on evaporation.
7. A refrigerant has a high heat of vaporization.
8. A refrigerant is a gas that can be easily liquified by pressure and cooling.

III. Energy--common forms of wave energy

B. Heat and infrared radiations

Measurement of heat

1. Temperature is not a measure of heat but of relative hotness and coldness.
2. The temperature of a material does not indicate its heat content.

3. The temperature of a substance is an indirect measurement of the speed of motion of the molecules.

4. The quantity of heat in a substance can be expressed in arbitrary units.

5. A definite quantity of water at a specific temperature is used as the standard for measurement of many heat characteristics.

6. The standards for units of heat are changes in temperat of stated quantities of water at specific temperatur

7. Cold is the absence of heat.

8. All temperature scales are arbitrary and man-made.

9. The common temperatures scales are Fahrenheit, centigrade (Celsius), and Kelvin.

10. Fahrenheit thermometers were developed without referen to reproducible fixed temperatures.

11. The centigrade temperature scale was developed with ze degrees as the freezing point of water, and 100 deg as the boiling point.

12. All substances contain heat energy until they are cooled to absolute zero.

13. Theoretically, at negative 273° centigrade no heat is present.

14. All molecular motion is assumed to cease at -273°C or -459°F.

15. The Kelvin temperature scale, or the absolute tempera scale, uses -273° centigrade as zero degrees.

16. At zero degrees on the Kelvin temperature scale all molecular motion ceases.

17. The Kelvin temperature scale is often used in working with high temperatures.

18. Extreme temperatures are usually expressed in degrees of the Kelvin temperature scale.

Cause of weather

1. Heat energy from the sun produces effects on the earth called weather.

2. Most of the air is heated indirectly by the sun.

3. The angle at which the sun's heat energy strikes the earth affects the amount of heat received in a given surface area.

4. The uneven absorption and reflection of solar heat is considered to be a prime factor in the earth's weather and climate.

5. As the sun heats masses of air near the earth's surface, the changed density within the air masses causes movement.

6. When air rises from the surface of the earth, it expands and cools.

7. The heat released by condensing water vapor is the source of most of the energy in thunderstorms.

8. Relative humidity is the ratio of the amount of moisture present in air to the total amount of moisture it could hold at a specific temperature.

9. Dew point is the temperature at which moisture condenses or precipitates from the air.

10. Along the shore of a large lake, the temperature is increased when the water is freezing in early winter and is decreased in the spring when the ice is melting.

11. The presence of large quantities of water may prevent freezing of nearby areas for brief periods of time.

12. Smoke is made up of solid particles which are the products of combustion that are suspended in the air.

13. Most smoke rises because it is carried upward by hot, expanded gases, which are lighter than air.

14. Air, if trapped in small quantities within materials, usually retards the transfer of heat.

15. Modern aircraft are usually equipped with de-icing devices.

16. Ice forming on an aircraft produces aerodynamic changes which are hazardous to flight.

17. Structural icing usually occurs when the aircraft is in an area where moisture is visible.

gy--Common forms of wave energy

C. Sound

1. Sound is the physical vibration of matter.

2. A sound wave is a series of alternate condensations and rarefactions of air.

3. The length of a sound wave is the distance between two successive rarefactions or two successive condensations.

4. The velocity of sound varies with the conducting medium.

5. The velocity of sound varies with the temperature of the conducting medium.

6. Sound does not travel through a vacuum.

7. Pitch of a sound depends upon the number of pulses or waves per second traveling from the source to the ear.

8. The pitch of a sound increases with an increase in frequency.

9. The range of pitch heard usually differs from one individual to another.

10. An approaching sound has a higher pitch than a receding sound.

11. The greater the amplitude of a sound wave, the greater is the intensity of sound.

12. The acoustical properties of a classroom or auditorium depend upon the physical characteristics of the room and its contents.

13. Echos cannot be heard if sound is reflected by things near the origin of the sound.

14. An object can vibrate as a whole or in parts.

15. The vibration of one piece of matter may cause another piece of matter to vibrate in the same frequency (sympathetic vibration).

16. An object vibrating as a whole produces a fundamental tone.

17. Each vibrating part of a body gives a multiple of the fundamental tone called an overtone.

18. The fundamental tone combined with its overtones determines the quality of the sound.

19. Vibrating strings can produce musical tones.

20. The frequency of a vibrating string is inversely proportional to its length.

21. The frequencies of vibrating strings are directly proportional to the square of tensions.

22. The number of vibrations of vibrating strings varies inversely with their diameters and densities.

23. Some instruments use a column of vibrating air to produce musical sounds.

24. In a wind instrument the frequency of vibration varies inversely with the length of the column of air set in vibration.

25. The frequencies of vibrating air columns are inversely proportional to their lengths.

26. Some instruments use reeds to vibrate columns of air.

27. The frequency of reed instruments can be controlled either by the reed or the length of the air column.

28. Vibrating membranes produce musical sounds.

29. Bars can be used to produce musical sounds.

30. Energy of one vibrating object may be transmitted to another larger object thus increasing the amount of vibrating material.

31. There are some common devices for recording and reproducing sound waves.

32. Vibrations may be transmitted through a diaphragm to a recording instrument to make a permanent record of the sound.

33. Electronic devices have been developed to study and analyze sound waves.

III. Energy--Atomic structure and nuclear energy

A. Nature of the atom

1. An atom is the smallest particle of matter which cannot be divided by common physical or chemical processes.

2. The atom is the smallest portion of an element having the characteristics of that element.

3. An atom is the smallest part of an element which can exist and still be a sample of the element.

4. Each different kind of atom is a different element and has certain definite properties.

5. The atom itself is made of particles.

6. The atom is mostly space.

7. The electrons have a negative electrical charge.

8. The electron is very small in mass as compared to the neutron and the proton.

9. The electrons orbit the nucleus of an atom.

10. The distance between the orbits of the electrons and the nucleus is very great compared to the diameter of the nucleus.

11. The number of moving electrical charges differs with different elements.

12. The chemical activity of an atom depends on the electrons and their arrangement.

13. Under normal conditions electrons are not free to escape from an atom.

14. Each different kind of atom has a different number of orbital electrons.

15. The nucleus of an atom is very small as compared to the size of the entire atom.

16. Evidence seems to indicate that the nucleus of the atom consists of many different particles.

17. The nucleus of an atom is made of smaller particles.

18. The neutrons are in the nucleus of the atom and are electrically neutral.

19. The protons are positively charged particles in the nucleus.

20. A proton is extremely small compared to any atom, ion, or molecule.

21. The masses of protons and neutrons are approximately equal.

22. The nucleus contains almost all of the weight of the atom.

23. The weight of the atom is almost equal to the sum of the weight of the protons and neutrons.

24. In assigning the original atomic weights to elements, they are compared to oxygen which is arbitrarily assigned the weight of 16.000.

25. The weight of the electrons is so small that it is not significant in the atomic weight.

26. The number of protons in the atom is the same as its atomic number.

27. The protons within the nucleus of an atom repel each other.

28. There is a binding force(s) within the nucleus of an atom.

29. Energy is needed to hold the nucleus of an atom together.

30. When atoms have the same number of protons, they are atoms of the same element.

31. The number of electrons and protons must be equal in an atom.

32. Atoms of the same element may have different nuclei.

33. All atoms of an element have the same number of protons and electrons, although the nuclei may vary in the number of neutrons contained.

34. Isotopes are atoms which have the same atomic numbers or same number of protons but differ in their atomic weights.

35. The atomic mass is an average of the masses of the isotopes.

36. Different atoms of the same element may have different atomic weights.

37. The atomic structure of one kind of element differs from the structure of all other kinds of elements.

38. Forces in the atom are electrostatic and gravitational.

39. In the atom, gravitational forces are negligible as compared with electrostatic forces.

B. Fission

1. Machines have been devised which can be used to break up atoms into smaller particles than the atoms themselves.

2. Atoms of some elements can be changed into atoms of another element by bombardment with subatomic particles.

3. Probably the most important sub-atomic particles are the proton, electron and neutron.

4. The term "atomic energy" usually refers to the energy released in nuclear fission or fusion.

5. Nuclear fission and fusion reactions may be controlled or uncontrolled.

6. Some atoms have nuclei which are not stable.

7. Nuclei of the atoms of some elements disintegrate naturally over a period of time.

8. Nuclei which disintegrate spontaneously are unstable.

9. Atoms whose nuclei disintegrate naturally are said to be radioactive.

10. When a radioactive atom breaks apart, new elements are formed.

11. In a collection of atoms of a radioactive substance, energy is given off and new elements are being formed continuously.

12. Because of the large quantities of atoms of radioactive elements, energy and new elements are continually being formed.

13. Atomic fission may be produced by bombardment with a single neutron.

14. Nuclear fission breaks the nuclei of atoms.

15. A nucleus which separates has fissioned.

16. "Splitting of atoms" actually refers to splitting the nucleus of atoms.

17. Splitting of atoms or nuclear fission results in liberation of great amounts of energy.

18. During nuclear fission a small amount of matter is changed into a large amount of energy.

19. Matter and energy are really the same.

20. The supply of energy from the destruction of matter seems limitless.

21. Nuclear fission produces two or more products.

22. A product of a nuclear fission may be fissionable.

23. Fission may produce several neutrons which may cause further nuclear fission.

24. Fission of a nucleus may induce fission in other nuclei.

25. Nuclear fission produces different kinds of high energy particles and at least two new atoms of different elements.

26. Some elements are not found in nature but are man made.

27. Atomic nuclear fission or fusion releases a variety of radioactive atomic products and produces different atomic nuclei.

28. In addition to the proton and neutron, other particles have been detected which are released during the fission or fusion of nuclei of atoms.

29. Some radioactive materials emit alpha, beta and gamma rays.

30. The spontaneous emission of high energy radiation is called radioactivity.

31. An electronic device can be used to detect the presence of radioactive particles.

32. Radioactive isotopes are useful in locating some diseased tissues.

33. Some radioactive materials may be used in treatment of cancer.

C. Fusion

1. Nuclear fusion is the process of joining nuclei to form a new element.
2. Nuclear fusion is the combination of nuclei of certain atoms concurrently liberating energy.
3. Nuclear fusion takes place spontaneously in the sun.
4. Nuclear fusion produces high energy radiation.
5. When two or more atoms combine to form a different element, there is a slight loss of weight.
6. The matter lost in atomic fusion is turned into energy.
7. The energy received from the destruction of matter can be controlled for man's use.
8. Nuclear reactions are used in the production of large quantities of energy to carry on the world's work.

Aerospace--A summary unit

Delineation of content

This "Aerospace" unit is designed to summarize much of the science taught in junior high school. During the teaching of this unit, the teacher will need to review many of the concepts from all of the science units in grade seven, eight and nine.

Content from Grade Seven:

-"Plants" and "Animals", must be reviewed to revitalize the concepts related to man's requirements for life.

-The concepts concerned with the learning process may have special value when investigating steps in the training of astronauts.

-Concepts from the units, "Water" and "Air", contribute to an understanding of the importance of these environmental factors for life.

-Other concepts in the air unit add to an understanding of the earth's atmosphere.

Content from Grade Eight:

The grade eight unit, "Weather and Climate" contains concepts related to the problems of aviation and the aerodynamic portions of a space flight.

-Concepts from the geology unit which touch upon ores are indirectly related to the problems of rocket construction.

-In addition to concepts which contribute to an understanding of the characteristics of the astronomical bodies, the astronomy unit contains some concepts about time and star groups which when reviewed will give a better background for study of the problems of navigation in space.

Content from Grade Nine:

-The unit on "Energy from matter", contains concepts related to chemical methods of releasing energy and others which relate to the properties of the materials from which the rockets and space capsules are constructed.

-The concepts from the unit, "Energy, force and motion", are especially related to action and reaction as used in rocket engines.

-Concepts on acceleration, work and power and friction are also found in this unit.

-Other concepts in the unit, "Energy, force and motion" regarding gravity may be the beginning place for the study of weightlessness and the problems of slowing the descent of space vehicles as they approach the surface of astronomical bodies.

-The unit, "Electrical energy", can contribute to an understanding of the complex electrical systems used to power control and communication instruments of a space vehicle.

-The unit, "Common forms of wave energy", should lead to a greater understanding of the problems of seeing and hearing while in the near perfect vacuum of space.

-Also, from the unit, "Common forms of wave energy", the concepts on heat may make clearer the problems of temperature control in space vehicles.

-The fifth unit in grade nine "Nuclear structure and sources of energy", contains concepts valuable as a place to being an investigation of some of the suggestions which have been made for sources of energy and methods propulsion of space vehicles of the future.

In addition to all the above content, a few new concepts (listed below) are included in this unit. These concepts have been extracted from:

III. Energy

C. Mechanical energy and simple machines

IV. The Universe

F. Space travel

Aerospace

A. Air, aircraft, aviation

Lighter than air craft

1. Aircraft which are lighter than air have thin walled containers filled with material less dense than the surrounding air.
2. Inflated free balloons, which are lighter than air, float (drift) in air.
3. Inflated balloons rise until the downward and upward forces are in equilibrium.

4. The height to which a balloon can rise is a function of the density of air.

5. The volume of a balloon envelope varies with the quantity and temperature of the gas within the envelope and with the external air pressure.

Aircraft in flight

1. The energy of rising or falling currents of air affect aircraft.
2. Several forces act to provide lift for a heavier-than-air craft.
3. Air moving past wing surfaces of an airplane produces unequal air pressures on top and bottom of wing.
4. The greater the difference of air flow distance over a wing and under a wing, the greater is the decrease of pressure above the wing resulting in lift.
5. The greater part of the lift of an airplane comes as a result of the reduction of air pressure on the top surface of the wing.
6. Lift acting on the bottom of a wing results from impact pressure of air molecules.
7. The total lift of an airplane results from difference of forces on the top and bottom of airfoils.
8. The lift on a glider is the result of upward movement of air masses and/or the forward movement of the glider through the air.
9. As an aircraft wing passes through the air, which has perfect elasticity, the air molecules are pushed closer together and return to their previous spacing after passage.
10. Horizontally rotating airfoils can lift aircraft vertically.
11. Gravitational force exerts a downward pull on aircraft (weight).
12. An airplane can remain airborne only if the lift is equal to weight.
13. All airfoils in motion produce drag.
14. The effect of an airfoil moving through the air and of air moving past an airfoil is the same.

15. Propellers attached to crankshafts convert engine power thrust in some aircraft.

16. In an airplane, fuel energy used to overcome friction within the power plant does not produce thrust.

17. Propellers are airfoils so placed and shaped that, when rotating, lower air pressure results on the front tha the rear surface (thrust).

18. The position of some surfaces of an aircraft may be modified in flight to reduce resistance.

19. Parts of the propeller blades farther from the center move faster than those close to the center.

20. An aircraft in flight moves relative to the air (airspe and also relative to the ground (ground speed).

21. In describing the movement of an aircraft the point of reference may be the ground or the surrounding air.

22. An aircraft, regardless of the speed and direction of flight, is carried along by the current of air in which it is moving.

23. Speed of aircraft relative to the surrounding air is seldom the same as the speed relative to the ground.

24. Favorable air currents during the flight of an aircraft increase the ground speed.

25. The maximum altitude that can be attained by an airplan is dependent to some extent on the available power.

26. Jet power plants operate directly on the principle of action and reaction.

27. Some airplanes of the reaction type carry their own fuel and oxidizing agent (rocket planes).

B. Introduction to space travel

1. It is harder to get something to move than it is to kee it moving.

2. Air has inertia.

3. Objects moving through air require energy to overcome the friction of air.

4. The earth's atmosphere does not have a finite boundary.

5. The density of the atmosphere decreases with the distance away from the earth.

6. Interplanetary space is considered to be a near vacuum.

7. Outer space is as near a perfect vacuum as man is able to conceive.

8. An object at higher altitudes in the atmosphere requires less speed to surpass the speed of sound.

9. The speed of sound is dependent upon the density of the transferring medium.

10. Distances in astronomy are often measured in multiples of the distance from the sun to the earth (astronomical unit).

11. Satellites including the moon which are orbiting the earth are moving away from the earth at the same speed as the gravitational speed toward the earth.

12. The orbital speed of an artificial satellite is dependent upon the satellite's orbiting distance from the earth.

13. In order for an artificial satellite to orbit the earth, there is a minimum linear velocity which it must attain.

14. To cause an object to revolve in an orbit, a centripetal force must be applied (inward).

C. Navigation and guidance in space travel

1. Rockets may be guided so that they will land on orbit, collide with, circle around astronomical bodies and return safely to earth, or travel endlessly in space.

2. Guidance systems of rockets must control the direction and speed in order to permit safe re-entry of rockets to the atmosphere.

3. The reaching of a specific position in space must be calculated previous to take-off.

4. To reach a specific position in space all variable factors influencing the direction of movement must be controlled.

5. Aiming of space vehicles must include "leading the target".

6. The fuels for extended space travel could be materially conserved by launchings from a space station rather than from the earth.

D. Communication in space travel

1. Electromagnetic waves from outer space and telemeterings from space satellites are currently being received.

2. Certain electromagnetic frequencies used for communication are of little use during magnetic storms.

3. Soon after the formation of sunspots there are exhibitions of northern and southern lights, and magnetic storms which make communication difficult.

E. Biological and physical problems in space travel

1. During space travel man must be protected from extremes of heat, cold, air pressure, oxygen, nitrogen (as a diluent) and carbon dioxide.

2. In order to travel at extremely high speeds in the atmosphere, man must travel at high altitudes.

3. Weightlessness is a phenomenon which results from the decrease of the effective gravitational pull of the earth.

4. The farther away from earth something is, the less the earth pulls it.

5. In space the greater mass exerts the greater force.

LEARNING
EXPERIENCES

REGULARITIES IN THE WEIGHTS OF COINS

Experiment 4

The purpose of this experiment is to enable you to (1) gain skill in presenting data in useful form, and (2) review the activities of science as outlined in chapter one of your text.

In the laboratory you will weigh various coins and combinations, recording your data on the blackboard. Here you are, of course, MAKING OBSERVATIONS by collecting information by weighing. In part II of the write-up of results you will SEARCH FOR REGULARITIES by considering the implications of the graphed data. In part III you are asked to ATTEMPT EXPLANATION for any regularities discovered, and possibly to suggest further observations which might test your explanations. These three processes, making observations, searching for patterns or regularities, and attempting explanations (creating theories) constitute what all scientists do, or have ever done, in accumulating scientific knowledge.

PROCEDURE

(1) Weigh to the nearest 0.01 gram (a) two, five, or ten pennies and (b) one, two or three nickels. Record your values on the front board.

(2) Weigh any single coin, or combinations, of dimes, quarters, halves or dollars dated BEFORE 1965. Enter your values on the blackboard after each weighing. Note the columns on the board which require more values (at least five) and help fill them with additional weighings.

(3) Do the same with dimes, quarters, and halves dated AFTER 1965.

(4) Record the collated values from the front board when you complete your weighings.

RESULTS

(1) Graph the weights vs. values of the coins on graph paper.

You will be able to plot all the data, and get best results, if you connect four sheets of lab notebook paper to make a sheet four times as large. (This is made easier if you attach the sheets first with two bits of scotch tape for lining up the squares before glueing.) Leave about 3 or 4 spaces for margin for labeling the axes, draw an abscissa and ordinate, and then mark off the units. Mark off 1 gram per two spaces on the ordinate for weight, and 10¢ per four spaces on the abscissa for value. Be sure both units start at zero at the origin. You may elect to use a single page of graph paper. If so, even greater care must be used in locating points. Use a scale one-half that indicated above. The longer edge of the graph paper should run vertically, so that the ordinate can extend from zero to 35 or 40 grams. Value, on the abscissa, should extend from zero to $1.25 or $1.50.

(2) Plot each point with care, using a sharp pencil. Do not take an average weight for each value, since plotting each point gives a visual indication of the uncertainty in each value. Some points will fall on top of one another especially for the small value coins. Realize that care in weighing is lost

Experiment 4 -- (continued)

if equal care is not used in plotting. After each point is plotted, a tiny circle, triangle, square, or diamond should be drawn around it. This is a standard graphing technique, used to make the points easier to see. When points are connected, the line should extend up to, but not through, each circle, etc., and then continue on. No plotted point will be covered up by a line passing through it, therefore. Note the examples below.

——⊙—— (use circles for old "silver" coins)

——△—— (use for new "silver" coins)

——⊡—— (use for "silver" dollars and combinations)

——▽—— (use for nickels)

——◇—— (use for pennies)

(3) When the points are all plotted, connect the appropriate ones. How many lines do you think are called for? Label each to easily identify it. Does each run through the origin? (If not, you have made a mistake in plotting, or in labeling units on the axes. Check these.)

PART II Seeking Regularities

(1) Does a straight line represent a regularity? Of course. Are there other regularities which the plotted data suggest? Yes. Can you write down in sentence form the regularity suggested by a straight line graph? Can you state any other regularities suggested by the data? (The regularity that two nickels weigh twice as much as one is a possible one to state, but is hardly important: we knew that before we started. Try to seek regularities which were revealed only by collecting and graphing of the data. For example, can you state a regularity which exists for the combinations of either the pre- or post-1965 "silver" coins which you didn't realize before?)

(2) A data table, a graph, and written statements are all important ways of communicating information. But one of the most useful ways of expressing a quantitative regularity is a mathematical equation. If you are able, write an equation for the post-1965 "silver" coins line. An algebra book will help you recall how to do this.

(3) Determine the value of (a) one gram of pre-1965 "silver" coin metal and (b) one gram of post-1965 "silver" coin metal. This can be done using the graphs, or from an equation. State which you use.

PART III Seeking Explanation (Optional)

(1) If a regularity exists for, say, the pre-1965 "silver" coins, can you suggest an interpretation as to why this regularity exists? (Be careful not to simply restate the regularity here, but to suggest a possible reason why it exists.)

(2) Is your interpretation necessarily true? If not, is there a way or ways to test if it is? If you can think of any, write them down.

General Information and Suggestions for the Coin Exercise

(1) Prelab.

Instruction in the use and handling of the centigram balance should preceed this exercise. Students should be reminded several times in advance to bring a variety of coins, including silver dollars if possible.

(2) Laboratory

Data tables, such as follows, should be drawn on the chalkboard for student entries. This plan makes it easy for students to collect and record data as a class. About four or five entries per value is suitable.

Pennies		
2¢	5¢	10¢
6.22		
•		
•		
•		

Nickels		
5¢	10¢	15¢
5.00		
•		
•		
•		

Pre-1965 "silver" coins including silver dollars										
10¢	20¢	25¢	35¢	50¢	70¢	75¢	*100¢	120¢	125¢	150¢
2.52		6.30		12.6			*26.70			
•										
•										
•										

Post-1965 "silver" coins										
10¢	20¢	25¢	35¢	50¢	70¢	75¢	100¢	120¢	125¢	150¢
2.29		5.72		11.5						
•										
•										
•										

*All weights which include a silver dollar must be marked with an asterisk in the last four columns for pre-1965 "silver" coins.

Numerical entries in the above tables are the weights of a newly minted single coin of that value. All weights are in grams.

(3) Postlab.

This exercise serves a useful purpose at several levels. First it gives practice in the use of the centigram balance before it is used in critical chemical experiments. It has the advantage that students get a self-check by comparing their weights with others immediately. Secondly, students learn careful graphing techniques, or at least review them. The search for regularity perhaps makes clearer, by example, what this activity of science is all about. The search for explanation is frosting for more capable students.

(4) General Information on Coins

The pre-1965 silver coins are sterling silver: 90% silver and 10% copper. The post-1965 quarters and dimes contain no silver and are a sandwich of three layers. The inner core is copper and the surface layers are an alloy of 75% copper and 25% nickel, the same alloy used in the old nickel. The post-1965 half dollar is also a sandwich, the core being 21% silver and 79% copper and the surfaces 80% silver and 20% copper. The overall silver content is 40%. New coins weigh 9% less than the old counterparts.

djb
12/21/66

MINNEAPOLIS PUBLIC SCHOOLS
Science Office

A SCIENTIFIC ATTITUDES CHECK LIST

Directions:

All of us have heard about the attitudes of scientists as they go about their work of investigation. In our textbooks we have seen lists of these "Scientific Attitudes" and have had to memorize them to be mentally regurgitated during an examination, but few, if any, of us can put the meaning of these scientific attitudes into common everyday language. What must a person do to give evidence of having acquired or not having acquired these scientific attitudes? The purpose of the tabulation which follows is to help you determine to what extent you have acquired these scientific attitudes.

Read carefully each scientific attitude, as well as the four pieces of evidence in the second column, and choose that evidence which best fits you. Place a check in the right hand column opposite the rating for the evidence which best describes you. Now read the attitudes and check.

The purpose of this rating blank is for your own self-evaluation. After reading and checking as described above, you have some idea of how scientific you are in your attitudes. But let's make it quantitative. For each check opposite each rating that you have given yourself, write in the point values from the following table:

Poor................	5 points
Fair................	10 points
Good................	15 points
Excellent...........	25 points

Now add your points for each scientific attitude and establish your total score.

40 - 60 points.	Don't plan for a career in science!
65 - 105 points.	Your greatest contribution to science will be the washing of flasks, test tubes and animal pens.
110 - 145 points.	You can with great effort perhaps become a member of a staff research team.
150 - 200 points.	You can have a future in scientific research!

A SELF-RATING CHART OF SCIENTIFIC ATTITUDES

Scientific Attitudes	Evidence	Rating	My Score
1. Desire to know	a. Cannot think of one question you would like to have answered.	Poor	
	b. Think of questions you would like to have answered but never try to find the answer.	Fair	
	c. Think of questions to which you would like to know the answer but depend on others to find the answers.	Good	
	d. Make lists of the questions you would like to have answered and then proceed to try to find the answers to them.	Excellent	
2. Willingness to spend time	a. Do not spend any time outside of science class studying science.	Poor	
	b. Do the assignments that are required.	Fair	
	c. Do the required assignments and volunteer for special reports.	Good	
	d. Do the required assignments, volunteer for special reports, and work on an individual project outside of class.	Excellent	

Scientific Attitudes		Evidence	Rating	My Score
3. Willingness to work	a.	Do not help with the work to be done during class.	Poor	
	b.	Work if you are asked to help.	Fair	
	c.	Volunteer to help with some class equipment and demonstrations.	Good	
	d.	Take a personal interest and responsibility in the appearance of the classroom. Help to clean up after class experimentation. Help to get equipment ready for class use.	Excellent	
4. Curiosity	a.	Do not ask questions.	Poor	
	b.	Ask questions if it is required of you.	Fair	
	c.	Ask questions about things which you do not understand.	Good	
	d.	Ask questions about things which you do understand and ask additional personal interest questions about other things in the field of science.	Excellent	

Scientific Attitudes	Evidence	Rating	My Score
5. Imagination	a. Do not suggest additional interesting learning activities for the class to do.	Poor	
	b. Suggest additional learning activities if you are asked to do so.	Fair	
	c. Suggest and occasionally become a leader in performing additional class learning activities.	Good	
	d. Suggest and lead class in unusual learning activities, good demonstrations and valuable experiments.	Excellent	
6. Openmindedness	a. Believe what you read and what you have been told.	Poor	
	b. Change your mind if enough people present evidence that you are wrong.	Fair	
	c. Question the statements of others and allow others to question your statements.	Good	
	d. Listen carefully to the questions others raise about your statements and then seek to submit evidence as to which idea is right.	Excellent	

Scientific Attitudes	Evidence	Rating	My Score
7. Withholding judgment	a. Accept as truth immediately what you hear and read.	Poor	
	b. Do not accept what you hear and read unless it is supported with evidence.	Fair	
	c. Find several authorities before you accept a statement.	Good	
	d. Seek the ideas of people who disagree with each other and keep both viewpoints in mind.	Excellent	
8. Respect for the ideas of others	a. Try to convince others that you are right.	Poor	
	b. Listen courteously to the ideas of others.	Fair	
	c. Engage in discussion with others who have differing ideas.	Good	
	d. Are challenged to study about the ideas of others so that you understand them better and can discuss these ideas of others from their point of view as well as your own.	Excellent	

Scientific Attitudes	Evidence	Rating	My Score
9. Excitement of discovery	a. Have no interest in the results of a learning experience or experiment except when something blows up or someone has an accident.	Poor	
	b. Like to watch others work out the calculations for an experiment so that you may copy their results in your write-up to be handed in.	Fair	
	c. Enjoy helping manipulate the materials during the experiment and make some of the necessary measurements.	Good	
	d. Know what you are looking for in the experiment and actively take a lead in setting up the apparatus in the most convenient fashion. Check to be sure all readings are accurate and records are made. Begin the necessary calculations as soon as all information is collected. Receive a thrill from finding the answers to your questions during the experiment. Enjoy discussing the experiment with those involved and those not involved in it.	Excellent	

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1-29-63

Here are
your
instructions
for
making

A SIMPLE ELECTRIC MOTOR

This educational pamphlet has been prepared for the National Electrical Week Committee through the courtesy of the National Electrical Contractors Association, Inc., for distribution throughout the United States and Canada.

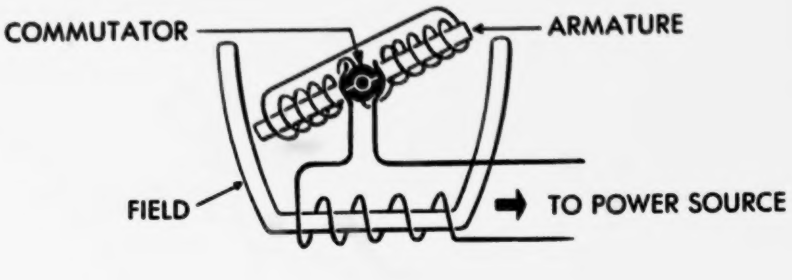
Any father
or youngster
can make a
simple electric motor
with just a
little wire and tape
...and this pamphlet.

THE ELECTRIC MOTOR has revolutionized our way of living. Motors are at work for us everywhere. In factories, on farms, on ships, in locomotives, far below the earth's surface in mines, high above us in airplanes and, of course, in our homes. You may be surprised how many motors there are in your home if you would stop to count them. They power your refrigerator, vacuum cleaner, phonograph, fans, oil burner and many other household devices. Even your electric clock is run by a simple kind of motor. And don't forget the powerful little motor that starts your car.

So it's an interesting and exciting adventure to make a motor yourself—even a crude one—to learn something about this marvelously useful and versatile servant.

What Makes a Motor Go? The same thing that makes a compass point north—*magnetism*. Any magnetic field (including that of our earth) has two poles, usually called the *north* and *south* poles. If you bring two magnets close to each other, you will find that the "like" poles (north and north, south and south) *repel* each other, while the "unlike" poles (north to south, south to north) *attract* each other.

This is the principle you will use in the motor you are about to make. You will be making two *electromagnets*. One (called the *field*) will stand still and the other (called the *armature*) will rotate. By reversing the magnetic poles in the armature at just the right moment as it spins, the poles of the field push the armature around. The part of your motor that reverses the poles in the armature is called a *commutator*. The diagrammatic sketch will help you see the relationship of these parts to each other.



Tools and Materials you will need to make your motor are simple and few.

For tools you should have a pair of pliers, pliers or cutters that will cut wire, a tack hammer, a knife, and a pair of scissors.

For power you will need one or two batteries. Bell batteries are the best but flashlight batteries will do. If you have two batteries, use them in series to try your motor the first time and to adjust it.

> To connect two *flashlight batteries* in series, put the "nose" of one against the base of the other. Then place the wires (ends scraped clean) from your motor against the base of the rear battery and against the nose of the other. To connect two *bell batteries* in series, use a short length of wire (ends scraped clean) and connect the *center* terminal of one with the *side* terminal of the other. Then connect your motor wires (ends scraped clean) to the two remaining terminals of the two batteries. Series connection of your batteries will give you 3 volts. Your motor should run well on one battery (1½ volts) when properly adjusted.

You may also use a *bell transformer* or a *toy train transformer* for power if you wish. Your motor is designed to work on either batteries (Direct Current) or a transformer (Alternating Current). *But do not use over 6 volts* or your motor will overheat rapidly.

Materials you will need are probably around the house now with the exception of the magnet wire. You will need a spool of No. 24 enameled magnet wire. You can buy this at an electrical store. Light, insulated bell wire will do, but magnet wire is much better. Remember that the enamel on the magnet wire is an insulator and that it must be scraped off at any point that an electrical connection is to be made.

Besides the magnet wire, you will need about seven feet of plain steel or iron wire. It may be galvanized or ungalvanized, but it should be about half the thickness of the lead in a lead pencil, for easy cutting and bending. Also, have a roll of friction tape handy (surgical tape will do), some tacks, two staples, a nail about 2″ long and a piece of wood for a base. Four by six inches is a good size for your base.

Let's make the field first

Cut 8 or 10 lengths of your steel wire about 6½ inches long. Put them in a bundle, with the ends even, as shown in Fig. 1. Hold the bundle together with a couple of turns of friction tape close to each end and wrap 2 inches of the center with a layer of friction tape.

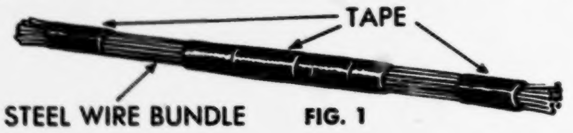


FIG. 1

Now bend your bundle into a semicircle (a little flat at the base) as shown in Fig. 2, and clip off any uneven ends of wire. Over the center taped section, wind five or six layers of magnet wire. Leave 8 or 10 inches of magnet wire for connection leads. Scrape the ends of the leads and test your field for magnetism with your power source. It should be attracted to any steel object or pick up tacks. Attach the field to the center of the wood base with two staples. Put a bit of tape under the staples where they grip the field wires. (Fig. 3)

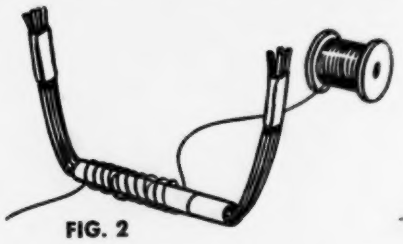


FIG. 2

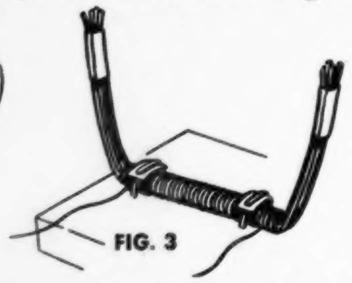


FIG. 3

Now for the Armature

Cut 8 or 10 lengths of steel wire, each 2½ inches long. Bundle them together and tape the ends. Take your nail and push it through the center of the bundle, with an equal number of wires on each side (See Fig. 4). Push it in until

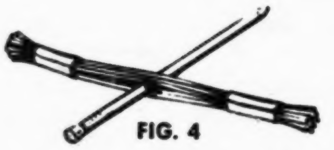


FIG. 4

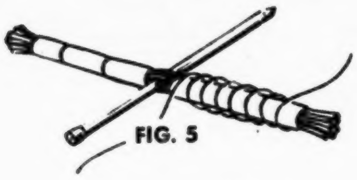


FIG. 5

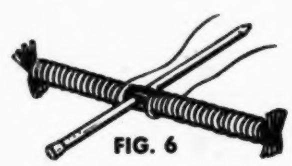


FIG. 6

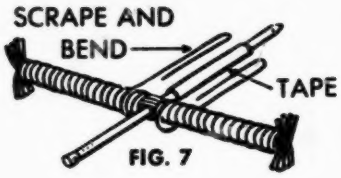


FIG. 7

two thirds of the pointed end is on one side. With pliers, press the wires together on both sides of the nail. *Be sure the nail is in the center of the bundle.* It will be the shaft, or axle, of the finished motor. Wrap a layer of tape around the rest of the bundle.

Now study Fig. 5 and start winding magnet wire on your armature. Start at the center and wind toward the end. When you have wound almost to ¼ inch from the end, start winding back. Keep winding, *always in the same direction,* till you reach the nail. Loop over the nail and wind the other side of the armature in the same direction and in the same way. Wind to ¼ inch of the end and wind back to the nail. Cut your magnet wire, leaving several inches on both leads. Bend the tips of the armature bundle wires apart, if you wish, to help keep the magnet wire from slipping off the ends. (See Fig. 6)

Make the Commutator next

Starting ¼ inch from the armature windings, scrape the enamel off both lead wires for about one inch. Cut off the rest of the leads. Wrap a layer of tape around the nail, starting at the armature and covering the nail to within ½ inch of the pointed end (See Fig. 7). Bend the lead wires as shown.

Look at Fig. 8 carefully. It shows how you should use two thin strips of tape to bind down the looped lead wires to form the commutator contacts. The two exposed contact wires formed by the loop from each side of the armature winding should lie along the taped nail, exactly as shown, half way between the armature windings. Four, evenly spaced wires will show.

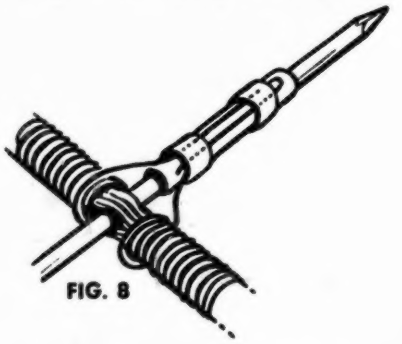


FIG. 8

Now for Assembly

Make two armature supports from steel wire as shown in Fig. 9. They should be just high enough to hold the armature inside the field and centered so there is no contact when the armature is turned. A twist of the wire supports around the nail forms the bearings. Make sure the twists are loose enough to permit the nail to turn freely. Put a drop of oil on both bearings. Now tack the supports in place. (See Fig. 11.) A strip of tape near the head of the nail will keep the shaft from slipping back and forth. Bend the field ends so that the ends of the armature just miss as they pass.

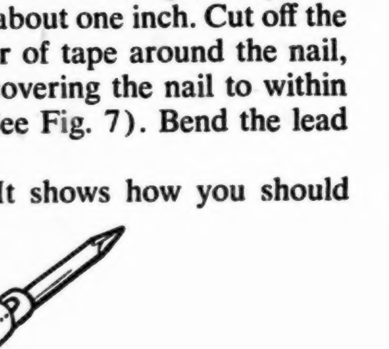


FIG. 9

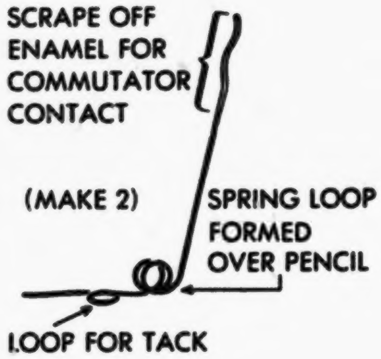


FIG. 10

Contacts for the commutator are made from pieces of magnet wire formed as shown in Fig. 10 and mounted as shown in Fig. 11. Be sure the ends are well scraped and be sure that they rest firmly against the commutator after mounting.

Take the lead leading from one of the commutator contacts you have just mounted and connect it to one of the leads from the field coil. The other commutator contact lead and the other field coil lead connect to your battery or transformer. Make sure all connections are made with *scraped* wire ends.

Depending on the position of the armature, it may need a little push to start it once you have connected the motor. To adjust your motor to get most power and speed, try twisting the commutator assembly very slightly, first one direction and then the other, around the shaft nail. If rotation is jerky, try moving the commutator loop wires together a little or apart a little. With a little experimenting and patience, your motor should spin in a very businesslike way with only 1½ volts of battery power.

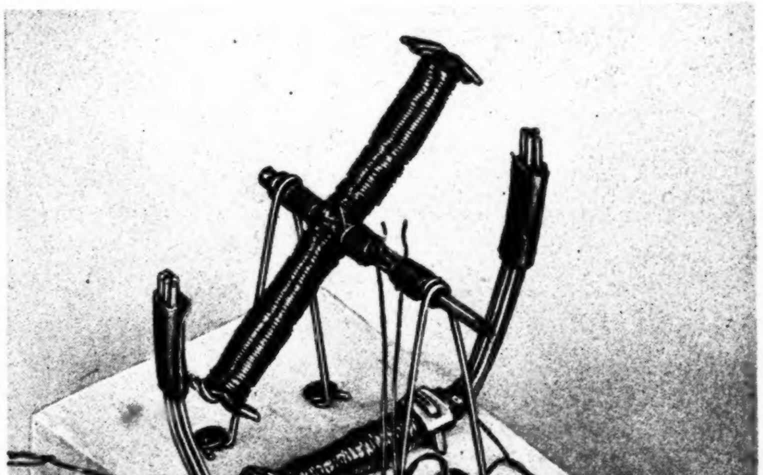


FIG. 11

Electricity

...IMAGINE YOUR LIFE WITHOUT IT!

NATIONAL ELECTRICAL WEEK

NATIONAL ELECTRICAL WEEK COMMITTEE
90 Madison Avenue • New York 17, N. Y.

● IMAGINE, if you can, what your life would be like without electricity.

Imagine a world without electric lights... without radio, television, motion pictures... without electric clothes washers, irons, refrigerators, food mixers, vacuum cleaners... without X-ray and electrocardiograph equipment... without electrically powered machine tools and office equipment... without whole industries that are dependent on electric power.

How different a world it would be from the one we know! So different that it's hard to realize that the changes in our civilization that have resulted from the harnessing of electricity have taken place in the short space of a man's lifetime — in the 80 years since Thomas A. Edison invented the first practical incandescent lamp.

With that invention, one of the major break-throughs in industrial progress, the way was open to a new world. An industry that was to become one of the nation's largest and most vital was born.

Since Edison's invention, the electrical industy has grown to the point where it now employs directly more than 3,000,000 persons — or 1 out of every 20 of our nation's workers. How many others owe their employment indirectly to electricity is incalculable. Virtually every industry in the nation is dependent on electric power to some degree. In the manufacturing industries, the average worker now has the use of electricity equal to the energy of 374 men, and that figure is growing year by year. Some vital industries would never have developed without electrical equipment and electric power in large quantities to drive it. Aluminum, for example, cannot be produced without electric power. The chemical and petroleum industries could not exist as we know them without electricity; nor could the communications and entertainment industries.

The use of electricity in the United States has at least doubled every ten years since the turn of the century and, as production has increased, costs have declined. In 1929, the average American home used 502 kilowatt hours a year at a cost of 6.33 cents per kilowatt hour. Since then, this annual use has increased 6½-fold and the cost has dropped to an average of 2.53 cents per kilowatt hour.

In the 80 years since Edison's epoch-making invention, electricity has become available in abundance and at low cost for use in countless ways that contribute to our health, our safety, our national strength and to our high standard of living. In short, these past 80 years have been a period of tremendous progress for the electrical industry and the nation it serves.

This record of progress is the reason for National Electrical Week, which is observed annually during the week of Edison's birthday, February 11.

During this week, the men and women in all of the various groups that make up the electrical industry join together to pay tribute to Edison and the other pioneers of electrical progress, to celebrate their industry's past accomplishments, and, most important, to rededicate their industry to continuing progress and service to the nation.

Headquarters for Observance Materials
ATIONAL ELECTRICAL WEEK COMMITTEE 407 N. 8th ST., SUITE 306, ST. LOUIS 1, MO., CEntral 1-1733

THREE SCIENCE PROJECTS

A THERMOELECTRIC CONVERTER

By the 1960 Schenectady Creative Engineering Program, General Electric Company

Description	Size and Amount Needed	Place to find	Estimated Cost
Insulated copper wire (magnet wire or bell wire).	12 feet of number 18.	Radio or TV repair shop —Radio parts store— Hardware store.	39¢ for ¼ pound spool of 36 feet.
Galvanized iron wire.	One foot of number 18.	Hardware store.	19¢ for a ¼ pound coil.
Small magnetic compass.	One to 1½ inches in diameter.	Scout compass, surplus store, or sporting good store.	50¢
Candle.	Large.	Home or buy at the hardware store—ask for a "plumber's candle".	10¢
Soft wood board.	½ inch x 8 inches x 12 inches.	Scrap pile.	—
Tin can.	3 inches dia. or larger.	Home.	—
Two small wooden blocks, adhesive tape, and glue.	—	Home.	—

MATERIALS CHART

Total $1.18

LOOK AROUND you and see all the things that run on electricity. Where does this electricity come from? It comes from the sun! Millions of years ago the sun aided in the growth of plant material that was later transformed into coal. The coal was mined, crushed, and sent to a power plant. There the coal was burned, changing water into high-pressure steam. The steam was blown through a giant turbine which turned, driving the huge generators that produce our electricity.

In recent years scientists have been working on a way to cut out most of these steps by using the thermoelectric generator. A thermoelectric generator transforms heat from the sun or other source directly into electricity.

How is this electricity made? Here is one way. If wires of two different metals are joined at the ends and one joint heated while the other is left cold, a tiny voltage will be generated and an electric current will flow around the loop. Although this effect has been known for more than a hundred years, very little has been done about it except to develop and use electric thermometers called 'thermocouples' and 'thermopiles.' The reason that so little attention was paid to this effect is that the voltages produced were so small that an efficient electric generator could not be built. But recently it was discovered that certain semiconductor materials can produce thermoelectricity much more efficiently than anything used before. Even better materials are needed before thermoelectric generators will replace our power plants, and possibly to make the electricity to drive the electric automobiles of the future. Perhaps some day you will be the scientist that discovers the new material, or the engineer that designs and builds the first of these new power plants or electric automobiles.

Right now you can build a tiny thermoelectric generator, see it work, and do some experimenting with it. You won't be able to make very much electricity; in fact, a thousand of these generators would just barely be enough to light a one-cell penlight bulb. So, you will have to build a compass galvanometer to detect the tiny amount of electricity produced by your thermoelectric generator.

The main things that you will need to build your thermoelectric generator are listed on the accompanying chart.

Read all of the steps through once and study the figures first. Then start with step number one:

1. Remove the top from the tin can if it is not already gone. The can will act as a chimney and protect the candle from outside breezes.
2. Punch three evenly spaced holes about the size of a dime in the sides of the can

near the bottom. These holes will provide an even draft for the flame and keep it steady.

3. Cut the candle an inch shorter than the height of the can.

4. Light the candle and drip some hot wax into the center of the can. Quickly put out the candle and mount it in the melted wax.

The next three steps tell you how to wind the coil for your compass galvanometer.

5. Find a round object the same diameter or slightly larger than your compass to wind the coil on. It should be small, since that will make the most sensitive galvanometer, but not so small that the compass can't fit inside it.

6. Wind about 20 turns on your form, leaving 16 inches of wire on one end and 10 inches on the other to make connections to. See Figure 1.

7. Let the coil unspring from the form. Gather it together and tape it at two places to make a neat bundle of wires.

Now you are ready to make the junctions. This is the hardest step, so follow the directions carefully. You might want to try making some joints on scrap pieces of wire before doing the real ones.

8. Scrape with a knife and then use sandpaper to get *every bit* of insulation from 1½ inches of the ends of the copper coil. Some copper magnet wire has transparent enamel on it that is difficult to remove.

9. Cut 6 inches of iron wire and sand the ends lightly to make sure they are clean. The iron wire will not have insulation on it.

10. With your fingers, wrap about 5 turns of the bare end of the copper wire *as tightly as possible* around the iron wire. See Figure 2.

11. Bend the end of the iron wire back against the copper turns and pinch it in place with a pair of pliers. Figure 3 shows a finished junction. Your joints must be made clean and tight in order to allow the small current to flow easily through them.

12. Make the other junction the same way so that the iron wire joins the ends of the copper coil.

13. The object of this step is to mount the coil around the compass as shown in Figure 4. First make the wooden blocks the right size so that the compass can sit right in the middle of the coil. Figure 5 may help you to see how to mount your coil. Glue the blocks in place, and hold them down with a piece of tape that goes through the coil and all the way around the mounting board. Don't use nails since they might attract the compass needle.

14. Set the can with the candle inside on the opposite end of the board from the coil. Bend the wires so that they look neat and so that one junction will be in the candle flame. Staple or tape the wires in place.

15. The last step is to set the compass on the small blocks of wood inside the coil. Be sure the needle is not being attracted by nails or steel parts beneath the board or nearby. Before lighting the candle turn the entire board until the compass needle lines up with the coil as shown in Figure 5.

Now you are ready to try it out. Light your candle. If everything was done right, the compass needle should turn slowly about 25° to one side. This happens because the hot junction and wires produce a voltage that makes a current flow in the coil. The coil acts like an electromagnet, setting up a magnetic field along the axis of the coil. The compass needle tries to line up with this magnetic field and so moves from its normal north-south position. The more the needle deflects, the more current is present.

But before long the needle will stop and turn back. As the joint gets very hot the needle may even go back beyond the place where it started! Why is this? Because the copper and iron generate voltage as shown in Figure 6. As the joint begins to heat the voltage increases. At about 640°F the voltage decreases, and at 475°F the voltage reverses and starts to build up the other way.

If you are interested in exploring the new field of thermoelectricity further, your science teacher and school librarian will be glad to find more information for you. In addition you might try the following experiments:

1. Find other kinds of wire to replace the iron. Do they work better?

2. Try connecting a flashlight battery in place of the iron wire to demonstrate how much more electricity is generated by the battery.

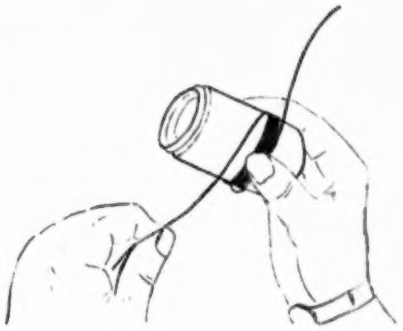


Figure 1

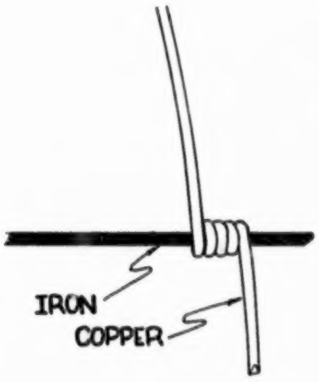


Figure 2

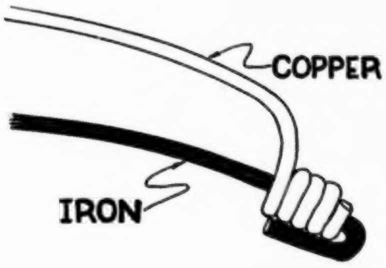


Figure 3

3. Heat the other junction and see if the compass deflects the other way. Why does it do this?

4. What will happen if you heat both junctions at once?

5. Get your science teacher to show you how to connect two or more junctions in series to get more voltage.

6. As a possible extension to your project, you might make a solar energy converter. All you need to do is get a large

magnifying glass, or a concave shaving mirror and focus the sun's rays on the hot junction. In this way you will be converting the sun's energy directly into electricity with no moving parts. Here are some hints to make your solar energy converter work better. Make the hot junction small and slightly black (from the candle flame). Put asbestos or aluminum foil right in back of the junction so that more of the heat is caught, and less escapes. Keep the rays focused at least a minute on the hot junction so that it will have time to heat up fully. Usually the largest diameter lenses or concave mirrors work best. Hold them in some kind of fixture if possible.

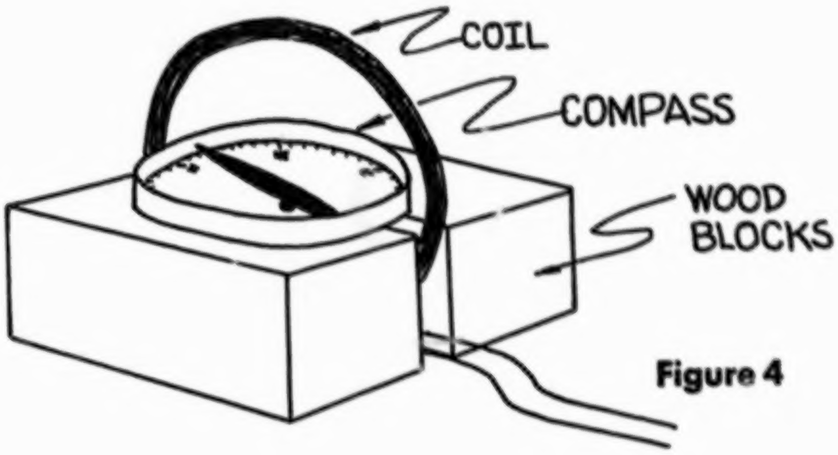
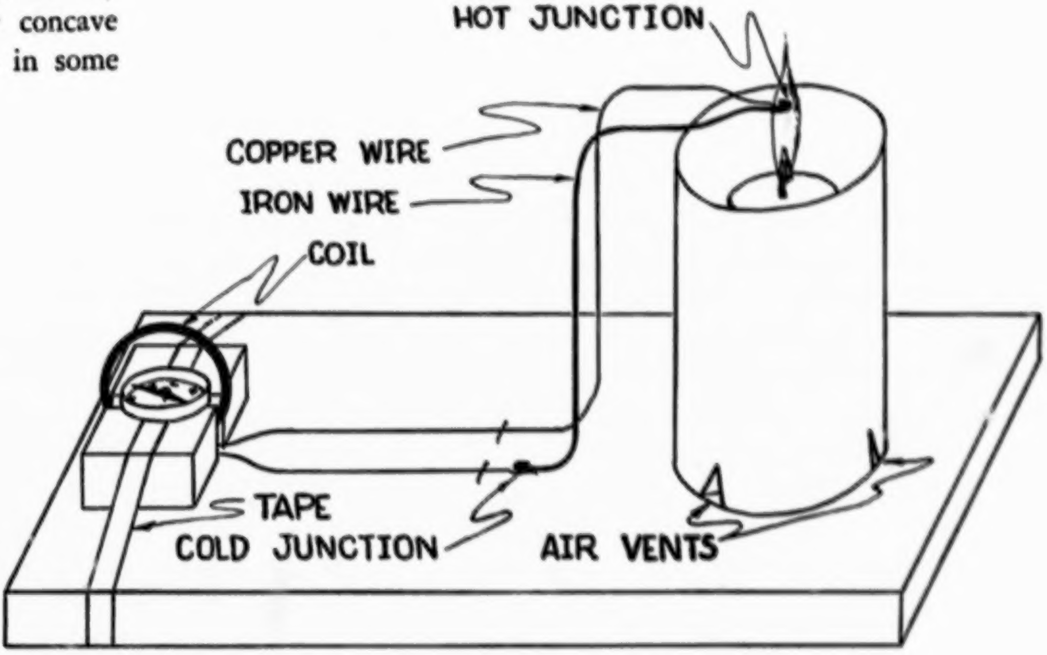

COIL
COMPASS
WOOD BLOCKS

Figure 4

Figure 5


HOT JUNCTION
COPPER WIRE
IRON WIRE
COIL
TAPE
COLD JUNCTION
AIR VENTS

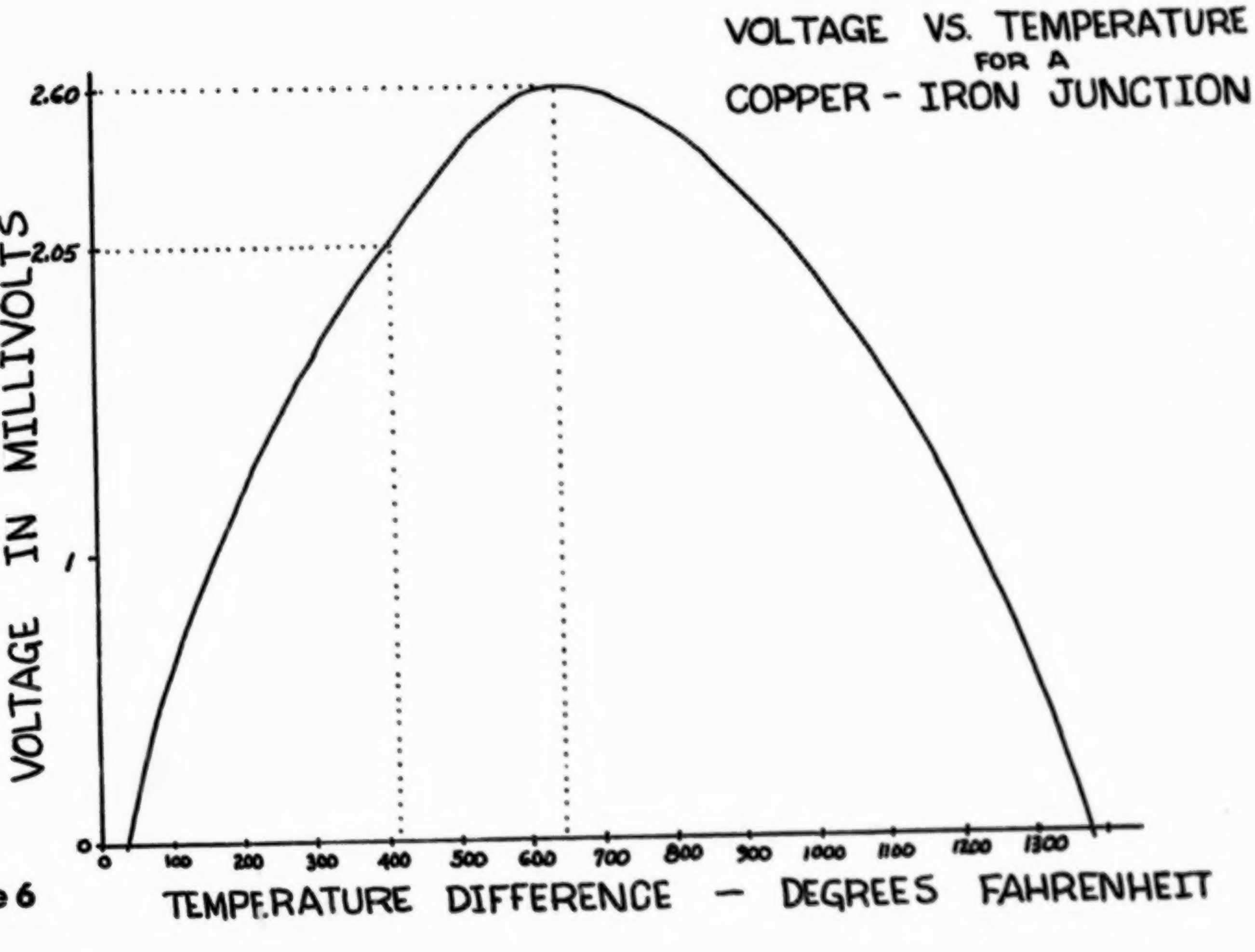


Figure 6

A CONTINUOUS CLOUD CHAMBER

THE CONTINUOUS cloud chamber is a unique instrument for studying certain properties of the atmosphere, especially with respect to various kinds of nuclei, cosmic rays, radioactivity, and cloud particles. It apparently was first used in Europe many years ago but more recently was developed for the study of cosmic rays and other types of high energy radiation by research scientists at the California Institute of Technology, the Brookhaven National Laboratories, and General Electric's own Research Laboratory.

The device is quite unlike the cloud chamber normally used for observing particles produced by ionization of the air, since it does not require the sudden expansion of an air sample to produce droplets.

A working unit may be made from two tin cans, a piece of felt, a glass jar, a cardboard box, a chunk of dry ice, and some hot water. The assembly of these articles is shown in the figure. The dimensions are not critical but are given to suggest the sizes which have been used to make a working unit.

The dry ice is obtainable from an ice cream store, creamery, or other business which ships perishable produce. If dry ice is difficult to obtain, ordinary ice may be used, either alone or chipped into a strong salt solution (use 1 part of rock salt to 3 parts of snow or chipped ice to make a strong brine solution). If ordinary ice or brine solution is used, it should be kept in a waterproof pan.

The dry ice should be put into a corrugated cardboard box. If two boxes are used, one inside the other with crumpled paper or other insulation between them, the dry ice will last longer.

A one-quart glass jar which is quite transparent serves as the cloud chamber. It may be placed directly on a flat piece of dry ice or preferably on a pedestal made of a tin can. The bottom of the glass jar should be two or three inches below the top edge of the cardboard box.

A piece of felt or cotton ¼"–½" thick should be fastened to the bottom of the other tin can with rubber cement or similar adhesive. It should be larger in diameter than the open top of the jar. After soaking it in water (or denatured alcohol obtained in a drug store), it should be placed on top of the jar and the upper can partly filled with hot water.

Shortly after the unit is assembled, a strong flashlight or other source of parallel light, when placed so that its beam illuminates the interior, will show the jar to be filled with a cloud of tiny water droplets. These are best seen by looking "up the beam"; that is, toward the light source and nearly parallel to it.

Close observation of the cloud in the chamber will show that the particles are falling. After twenty to thirty minutes, the particles will be few and far between and will be observed to fall very much faster than at the start of the experiment.

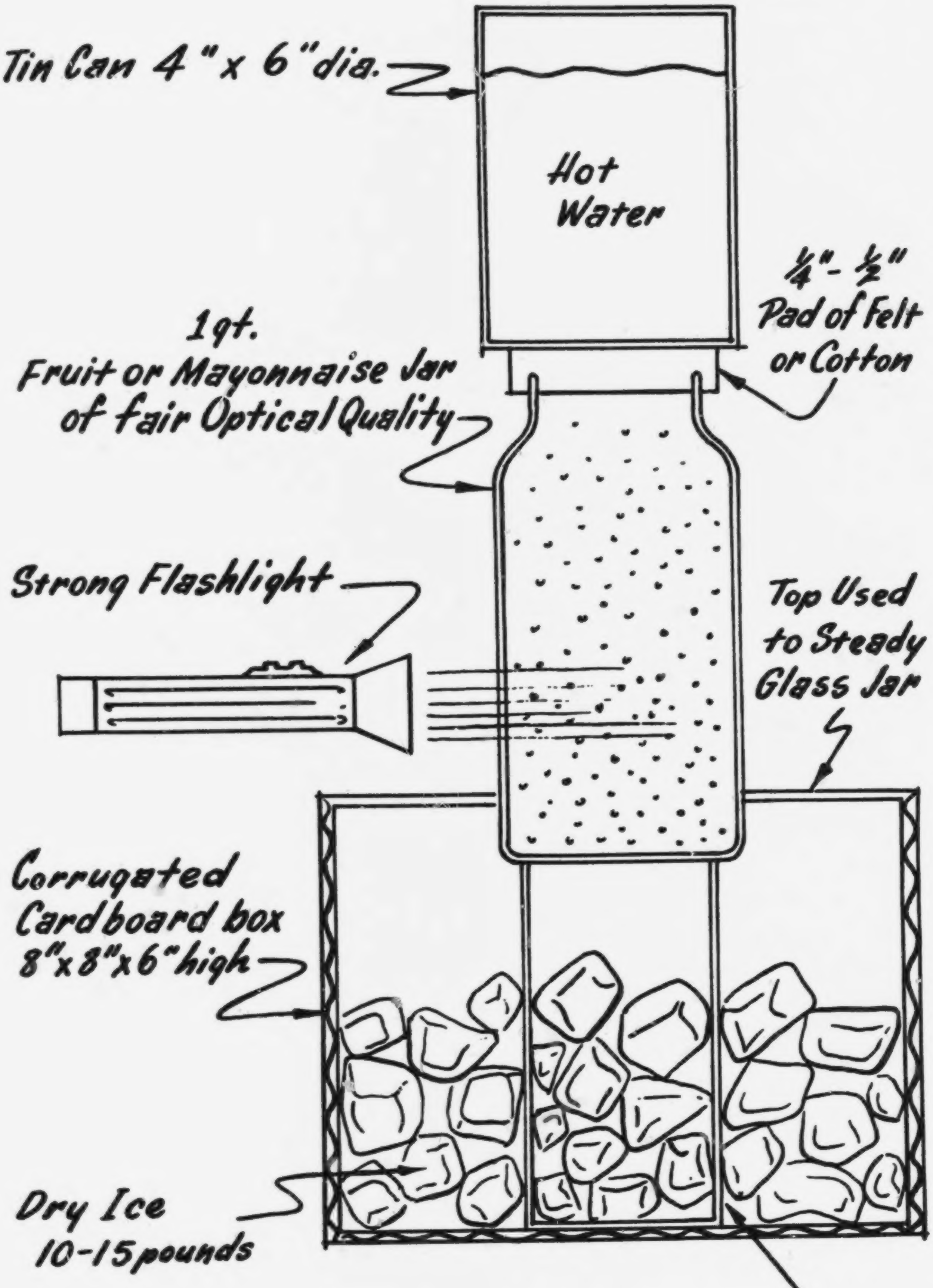
The reason for this is as follows. At the start of the experiment the air from the room which also filled the jar contained many submicroscopic dust particles called condensation nuclei. Moisture from the warmed pad at the top puts into the air large numbers of water molecules. Since there is a rapid cooling of the air column toward the bottom of the chamber, at a certain position (the dew point) the water molecules gather on the condensation nuclei to form a cloud.

Since there is a constant supply of water vapor at all times with a large number of nuclei in the air, each cloud droplet is very tiny and falls slowly. As the droplets reach the bottom of the chamber, they are "rained out," and after a while the number of such particles in the air sample becomes very small. In this way the remaining particles become larger so that they fall faster until finally the supply of nuclei becomes exhausted. Toward the end of this precipitation cycle, the particles approach the size and falling velocity of Scotch mist.

If denatured or methyl alcohol (obtainable at a drug store) is used in the pad it is not necessary to use as much of a temperature difference between the top and bottom of the chamber. Using these substances the air in the chamber becomes supersaturated once the concentration of condensation nuclei has been exhausted. At this time, one will suddenly see a large number of droplets formed along a line in the chamber resembling a sort of waterfall. This line of particles marks the sudden passage of a cosmic ray through the chamber. Such tracks form every few seconds as some of the air molecules become ionized (charged) by collision with cosmic rays coming from outer space.

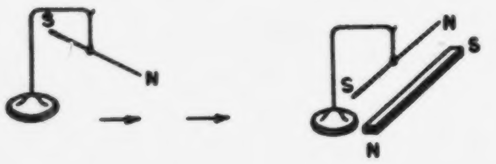
In order to see the effect of cosmic rays satisfactorily, it is necessary to use good illumination. It is also desirable if possible to use glass free of irregular lumps. The best cloud chamber is one made of four flat sheets of glass cemented together with a dark background on one side and all lights except the illuminator turned off. These are refinements, however, which are not needed for making the observations described earlier.

ASSEMBLY OF CONTINUOUS CLOUD CHAMBER

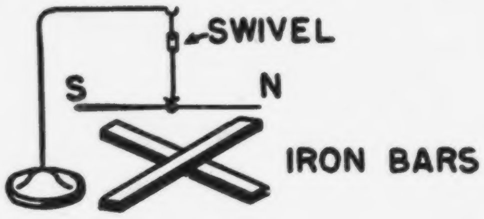

Tin Can 4" x 6" dia.
Hot Water
¼" - ½" Pad of Felt or Cotton
1 qt. Fruit or Mayonnaise Jar of fair Optical Quality
Strong Flashlight
Top Used to Steady Glass Jar
Corrugated Cardboard box 8"x8"x6" high
Dry Ice 10-15 pounds
Tin Can 4" dia. 4" high

WHY AN ELECTRIC MOTOR RUNS

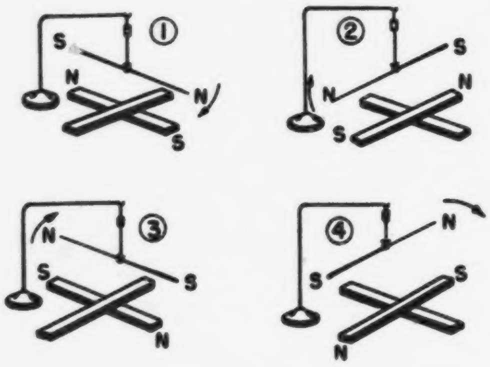
AN ELECTRIC motor has a stationary, or standing-still, member and a revolving member. Each has electric conductors in or around parts built up of thin iron strips or laminations. Electricity causes the revolving member to turn and do our work.



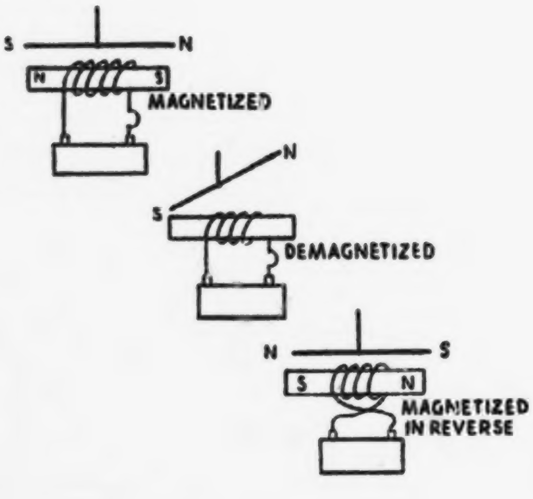
If a magnetized needle (S-N above) is free to turn, and if it is brought near a fixed bar magnet, it will turn vigorously to line itself up with its north and south ends opposite the south and north ends of the fixed magnet. This is something to remember about magnetism—*unlike poles attract, like poles repel....* And the turning needle does mechanical work.



Suppose one bar of iron is laid across another and the magnetized needle is suspended by a thread over the crossing point. The needle can point in any direction.



Now, if by some means the iron bars are magnetized and demagnetized so that the given poles appear in rotation, the free magnet turns to follow the successive locations of north and south poles. The needle magnet is thus made to revolve, and we have a miniature motor.



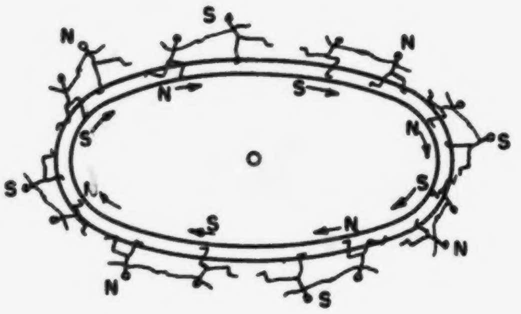
We have means for rapidly magnetizing and demagnetizing iron and reversing its north-south characteristic. A coil of wire around iron will make a magnet of it when electric current is passed through the wire. Because the iron is the proper kind, it will lose its magnetism instantly when the current is shut off. If the current is started again, in the reverse direction, the iron will be magnetized N-S where S-N was before. We say that the *polarity* is reversed.

This is an electromagnet — much stronger than a permanent magnet, and it can be controlled easily; that is, ON-OFF-REVERSE with great rapidity.

* * *

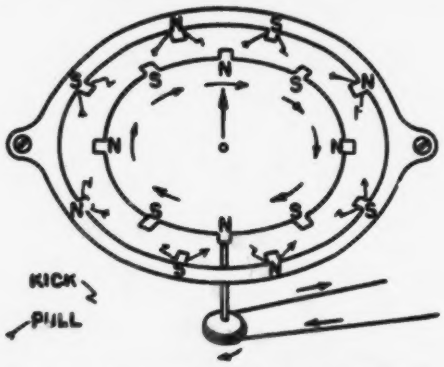
To go back to the motor—both the stationary member and the revolving member are largely electromagnets since the windings, through which electric currents flow, are around sections of iron. Sections of one member will be made alive-dead-alive with polarity reversed in regularly changing pattern. The sections of the other member will stay alive with polarity unchanged.

The reaction, or push-pull, between magnets makes it possible for one member to stay still and the other to revolve. The effort that makes a motor shaft revolve one way is trying equally hard to revolve the stationary part the other way. Whichever part is free to turn will turn. Motors are built with the unchanged polarity member (like the needle) either rotating or standing still, with the reversing polarity member standing still or rotating.

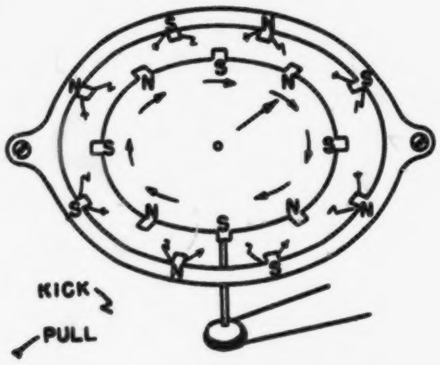


In this sketch, the poles (men) of the rotating member in the center are kicked along by the poles (men) behind and pulled along by the poles (men) ahead. As soon as a pole (man) comes abreast of a pole (man) that is pulling it, polarity changes; and a new set of kicks and pulls is established. To say this another way, the men on the inner circle are being kicked and pulled along. The men on the outer circle reverse their attitude as the inner men pass by.

The total of all these twists and pulls on all of the poles of the rotating member is the turning strength of the motor.

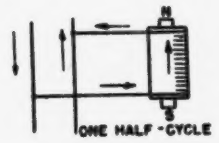


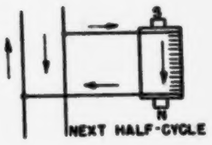
Watch the arrowed N. The poles of the revolving member are kicked and pulled by the poles of the stationary member.



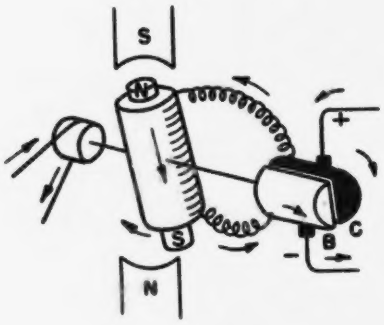
The arrowed N has moved to a new space, but it again has an N behind it and an S ahead.

Now poles are reversed in either of two ways. With alternating current—which most power companies provide for home use—the alternations themselves reverse the polarity of a magnet with each reversal of current flow.

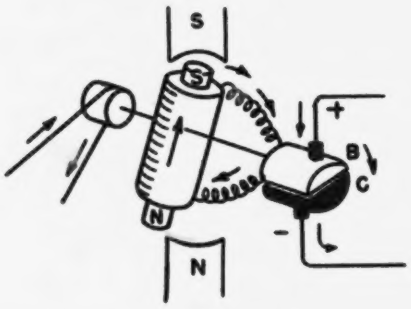




And that home current is probably 60-cycle current. That means that the current reverses its direction of flow 120 times each second. That means also, for our home motors, that the poles in one member reverse 120 times per second.



In a direct-current motor (direct current has a one-way flow), just as a moving north pole comes to a fixed south pole, its coil terminals (commutator bars B and C) make contact with brushes of opposite polarity, and the moving pole at the top becomes a south pole. The moving pole at bottom becomes north.

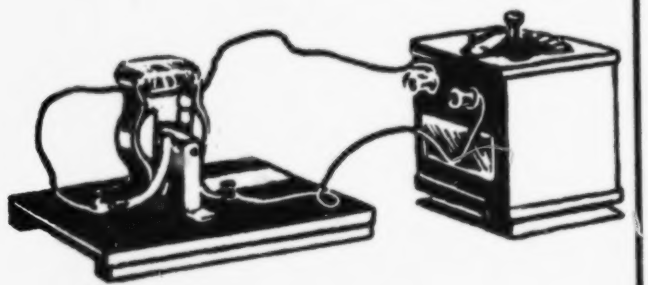


Here, the moving south pole (at top) is trying to get away from the fixed south pole; the moving north pole (at bottom) is trying to get away from the fixed north pole.

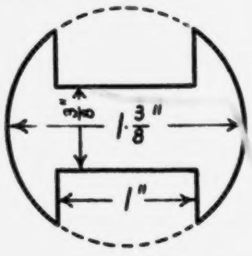
* * *

We may say that a motor runs because poles of one polarity are chasing poles of the opposite polarity and are kicked along by poles of the same polarity.

How to Make a TIN CAN MOTOR



ROTOR

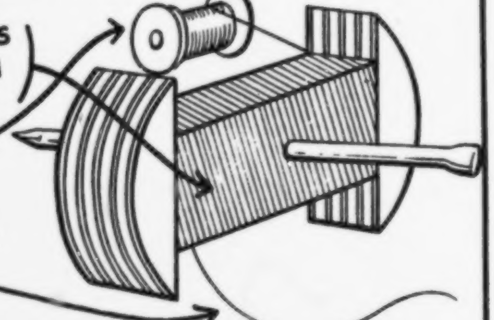


FROM THIS PATTERN CUT 5 PIECES OF TIN. DRILL CENTER HOLE TO FIT SNUGLY ON 2¼" FINISHING NAIL.

FASTEN 5 PIECES TOGETHER WITH ADHESIVE TAPE.

WIND MAGNET WIRE ON ROTOR UNTIL SPACE IS NEARLY FULL.

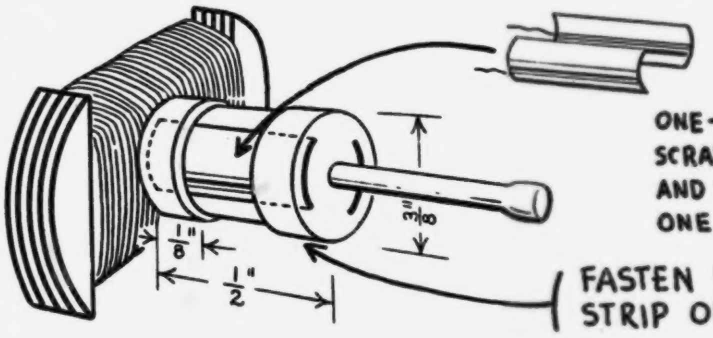
LEAVE 2" AT ENDS OF WINDING.



COMMUTATOR

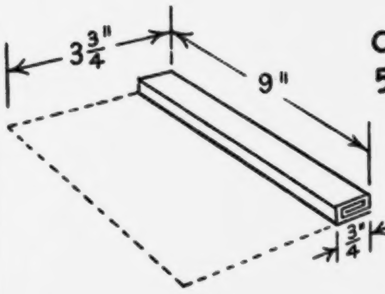
WIND ½" ADHESIVE TAPE ON NAIL CLOSE TO ROTOR. MAKE ABOUT ¼" IN DIAMETER.

CUT 2 TIN STRIPS ½" X ¼" TO MOLD AROUND ADHESIVE TAPE, EACH COVERING ABOUT ONE-FOURTH OF THE SURFACE. SCRAPE WIRE ENDS OF WINDING AND WRAP EACH END AROUND ONE OF TIN STRIPS.



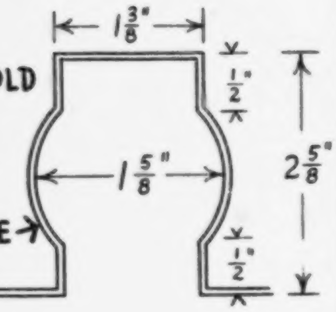
FASTEN IN PLACE BY ⅛" STRIP OF ADHESIVE TAPE.

FIELD, BRUSHES, AND ASSEMBLY

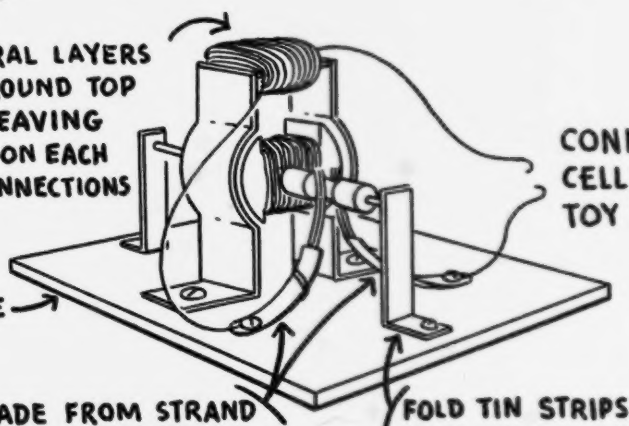


CUT TIN 3¾ x 9" AND FOLD 5 TIMES TO ¾" WIDTH AND HAMMER FLAT.

BEND TO THIS SHAPE



WIND SEVERAL LAYERS OF WIRE AROUND TOP OF FIELD LEAVING FEW INCHES ON EACH SIDE FOR CONNECTIONS



CONNECT TO 3 DRY CELL BATTERIES OR TOY TRANSFORMER.

WOOD BASE

BRUSHES MADE FROM STRAND WIRE WRAPPED AROUND TIN STRIP. CONNECT FIELD WIRE TO BASE.

FOLD TIN STRIPS TO ½" WIDTH TO FORM UPRIGHTS. PUT HOLE IN ONLY ONE SIDE TO SUPPORT NAIL.

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2-5590	----	MATTER, LIFE, AND ENERGY - HERRON LYONS. 1965 SUPPL 6-40 PER TCHR AVERAGE	9	4.05	---
5591	----	TEACHERS GUIDE 1965		.45	---
5592	---	STUDY GUIDE AND LABORATORY ACTIVITIES 1965		.99	---
2-5593	----	TCHRS ED OF STUDY GUIDE AND LABORATORY ACTIVITIES 1965		.99	---
2-5594	----	TESTS A 1965		.15	---
2-5595	----	TESTS B 1965		.15	---
2-5596	----	KEY TO TEST A 1965 TEACHER ONLY FREE W/ CLASS ORDER OF BOOKS			---
2-5597	----	KEY TO TEST B 1965 TEACHER ONLY FREE W/ CLASS ORDER OF BOOKS			---
2-5870	----	MODERN SCIENCE THREE - BLANC HOLT. 1963 SUPPL - 6-40 PER TCHR AVERAGE	9	3.60	---
2-5871	----	TCHRS EDITION FREE W/CLASS ORDER 1963			---
2-5872	----	EXERCISES & INVESTIGATIONS -WKBK 1963		1.11	---
2-5873	----	TCHRS ED OF EXERCISES & INVESTIGATIONS 1963 FREE W/CLASS ORDER OF WORKBOOKS			---
2-5874	----	TESTS 1 FREE W/EACH WORKBOOK 1963		.48	---
2-5875	----	KEY TO TESTS TCHR ONLY FREE W/CLASS ORDER 1963			---
2-7120	----	PHYSICAL WORLD - BRINCKERHOFF HARCOURT. 1963 SUPPL - 6-40 PER TCHR AVERAGE	9	4.05	---
2-7121	---	TCHRS MANUAL W/ANS TO TEXT & TESTS 1963 FREE W/CLASS ORDER		.75	---
7122	----	HARBRACE TEACHING TESTS 1963		.75	---
2-9100	----	WORLD OF MATTER-ENERGY - BRANDWEIN HARCOURT. 1964 AVG SUPPL 6-40 PER TCHR	9	3.75	---
2-9101	----	TCHRS MANUAL AND RESOURCE GUIDE W/KEYS TO TESTS 1964 FREE			---
2-9102	----	EXPLORATIONS IN SCIENCE -WORKBOOK 1965		1.20	---
2-9103	----	KEY TO WORKBOOK TEACHER ONLY 1965 FREE			---
2-9104	----	SCIENCE TEACHING TESTS 1964		.60	---

SCIENCE - GRADE 7,8,9 PERIODICALS - SUPPLEMENTARY

		CURRENT SCIENCE - WEEKLY AMERICAN EDUC. PUBL. SUPPL - 6-40 PER TCHR AVERAGE 16 ISSUES EACH SEMESTER	7 8 9		
2-1941	----	FIRST SEMESTER, EACH MIN ORDER 10 COPIES		.35	---
2-1942	---	SECOND SEMESTER, EACH MIN ORDER 10 COPIES		.35	---
2-1943	----	SCHOOL YEAR, EACH MIN ORDER 10 COPIES		.70	---
2-6020	----	NATURE AND SCIENCE AMERICAN MUSEUM OF NATURAL HISTORY SUPPL - 6-40 PER TCHR FORMERLY JUNIOR NATURAL HISTORY. 16 ISSUES EA SCHOOL YR.	7 8 9	1.40	---

NO. OF COPIES				TOTAL COST
	SCIENCE NEWS LETTER	7 8 9		
	SCIENCE SERV. INC. SUPPL - 6-40 PER TCHR AVERAGE			
2-7611 ---	PER YEAR		5.50	---
2-7612 ---	SCHOOL YEAR		3.13	---
	SCIENCE WORLD EDITION ONE	7 8 9		
	SCHOLASTIC. SUPPL - 6-40 PER TCHR AVERAGE			
2-7671 ---	FIRST SEMESTER, EACH		.85	---
2-7672 ---	SECOND SEMESTER, EACH		.85	---
2-7673 ---	SCHOOL YEAR, EACH		1.25	---

For discussion purposes only

A SELECTIVE BIBLIOGRAPHY

of

BOOKS FOUND USEFUL

in the

TEACHING OF THE SCIENCE UNITS

for
Grade Nine

Correlated to the Major Topics as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
2-4-66

For discussion purposes only

TABLE OF CONTENTS

Major Topics	Page Number	Color
Introduction to science	1	Gray
Energy from matter	3	Yellow
Energy, force and motion	5	Yellow
Electrical energy	6	Yellow
Common forms of wave energy	7	Yellow
Nuclear structure and sources of energy . .	8	Yellow
Aerospace	9	Blue

The annotations for books found on the following pages were obtained from many bibliographies which were consulted in the preparation of this list.

Introduction to Science

Piccard, Auguste 1956

* EARTH, SKY AND SEA

Oxford. $4.50

A noted twentieth-century explorer, physicist, scholar and proficient technician speaks of the invention of his bathyscape, his journey into the depths of the sea, and the scientific principles involved in his discoveries and adventures. Library referency only!!

* Teacher Reference Book

Energy from matter

Battista, O. A. 1959

* THE CHALLENGE OF CHEMISTRY

Holt, Rinehart, Winston $3.50

This book discusses the different opportunities for careers in the field of chemistry. A good library reference.

Cooper, Elizabeth K. 1959

DISCOVERING CHEMISTRY

Harcourt, Brace and Company $3.00

This is a good general introduction to chemistry. It contains information on how to set up a laboratory and also a number of experiments. It is a book that is easy to read and comprehend.

Dull, Metcalfe and Williams 1962

* MODERN CHEMISTRY

Holt, Rinehart, Winston $2.68

This is a chemistry textbook. A good reference book for the teacher.

Elwell, F. R. 1961

ATOMS AND ENERGY

Criterion $3.50

This book is an introduction to the principles of the atom, the history of atomic energy, and its contributions for young people. It explains atoms, molecules and their uses in a language that the student can understand. It gives a good description of many topics covered in the study of energy.

Feifer, Nathan 1959

LET'S EXPLORE CHEMISTRY

Sentinel $1.00

This is a book that treats the subject of chemistry thoroughly, and yet the language and experiments are simple enough to be easily understood by the ninth grade student. Very good!

* Teacher Reference Book

Energy from matter (continued)

Meyer, Jerome S. 1957

* THE ELEMENTS, BUILDERS OF THE UNIVERSE

World $3.95

Here, presented in clear non-technical language, is the fascinating, little-known story of the 92 natural elements and, since the splitting of the atom, the man-made elements that are the basis of life on earth. Graphically written and generously illustrated with photographs and diagrams, this book is a rich survey of the indispensable chemical elements that underlie and govern our physical world.

Mullin, Virginia L. 1961

CHEMISTRY FOR CHILDREN

Sterling $2.99

This book contains many good, interesting and practical experiments in chemistry that can be performed by ninth grade students.

Theiler, Carl R. 1963

* MEN AND MOLECULES: WHAT CHEMISTRY IS AND WHAT IT DOES

Dodd, Mead $5.00

This is a good reference book on chemists and their work in pioneering and discovery in the processes for production of paints, dyes, fuels, plastics, adhesives, etc.

Young People's Science Encyclopedia 1964

NEW FRONTIERS IN SCIENCE

Children's Press $6.60

This encyclopedia is an interesting, well illustrated student reference book which covers a wide variety of topics. It is easy to read and will contribute much to the ninth grade student's understanding of science.

* Teacher Reference Book

Energy, force and motion

Epstein, Sam and Beryl 1962

ALL ABOUT ENGINES AND POWER

Random	$2.37

This book uses simple vocabulary to explain the development of various methods for harnessing energy.

Irving, Robert 1960

ELECTROMAGNETIC WAVES

Knopf	$3.39

High school material is explained in easily understood language. The book contains a description of the nature of light, radio waves, infrared, ultra-violet, x-rays, micro-waves and gamma rays.

Irving Robert 1958

ENERGY AND POWER

Knopf	$2.75

This book is a fine resource for material on the concept of energy, work and power. It explains how man has learned to use and transform energy in its simplest forms to the present day technology. The information is simply stated so as to be easily understood by the student.

Mann, Martin 1960

HOW THINGS WORK

Crowell	$3.00

Excellent descriptions of the fundamental nature of ten modern mechanical devices, including the automatic transmission, cameras, telephones, television and recorders.

Schneider, Herman and Nina 1962

YOUR TELEPHONE AND HOW IT WORKS

McGraw-Hill	$2.75

This is a good explanation of how sound travels, how dial systems work, how exchanges operate, walkie talkies, phones in automobiles, etc.

Electrical energy

Reuben, Gabriel 1960

ELECTRONICS FOR CHILDREN

Sterling $2.99

This book contains much practical material and a number of simple pupil experiments for the study of electronics in the ninth grade.

Yates, Raymond F. 1942

A BOY AND A BATTERY (not revised edition)

Harper $3.50

The relationship between electricity and magnetism is described. Directions are given for making a battery connection and a detector. The book is rather elementary, but contains some good experiments.

Yates, Raymond F. 1944

A BOY AND A MOTOR

Harper $3.50

Clear instructions and diagrams are included to make this an excellent book in elementary electrical engineering. It also contains a background for the development of the electric motor and easy to follow directions on how to make some simple motors.

Common forms of wave energy

Freeman, Ira M. 1961

ALL ABOUT SOUND AND ULTRASONICS

Random House $1.95

A simple vocabulary and excellent illustrations are used to discuss wave motions, hearing, sound production (voice and instruments), ultrasonics and the sonic barrier.

Irving, Robert 1959

SOUND AND ULTRASONICS

Knopf $3.09

Includes sections on the nature and kinds of sound recording and transmitting and sounds we cannot hear. Easy to read.

Ruchlis, Hy 1960

THE WONDERS OF LIGHT

Harper $3.27

An excellent book on the properties of light. It discusses the behavior of light, light energy, illumination, kinds of light, optics and the difference between visible and invisible light.

Tannenbaum, Beulah and Myra Stillman 1960

UNDERSTANDING LIGHT

Whittlesley House $3.00

This is a good study of light -- well suited for the curriculum and age level. It covers topics such as: the sun, calculation of the speed of light, bending and bouncing of light, other forms of radiant energy, artificial sources and new uses.

Van Bergeijk, Willem A. 1960

* WAVES AND THE EAR

Doubleday (Anchor) $1.45

This is an interesting and complete reference book on sound for teachers or the better students. It covers sound waves and frequencies and discusses the ear and its function.

* Teacher Reference Book

Nuclear structure and sources of energy

Bischof, George P. 1951

ATOMS AT WORK

Harcourt, Brace $2.75

This book explains atoms, molecules and their uses in a language that the student can understand. It explains the molecular and atomic structure as a unit of matter; how liquids, gases and solids differ; how the molecules are related to different forms of energy.

Asimov, Isaac 1958

INSIDE THE ATOM

Abelard-Schuman, Inc. $3.50

This is a good reference book for students especially interested in this particular phase of science. It explains atomic structure, radioactivity, atom smashers and atomic fission and fusion.

Elwell, R. R. 1961

ATOMS AND ENERGY

Criterion $3.50

This book is an introduction to the principles of the atom and its contributions for young people. It explains atomic energy and gives a good description of many topics covered in the study of energy.

Haber, Heinz 1956

THE WALT DISNEY STORY OF OUR FRIEND THE ATOM

Simon and Schuster $4.95

This is an excellent and interesting book showing how scientists have developed the atomic theory. It covers the story of the atom in language that a student can easily comprehend. (Also a Walt Disney film)

Aerospace

Beitler, Stanley 1961

ROCKETS AND YOUR FUTURE

Harper $3.27

This is a good reference book on rockets and how they operate. It also mentions careers that are available in this field.

Caidin, Martin and Grace 1962

AVIATION AND SPACE MEDICINE

Dutton $3.75

About the atmosphere, pressures, g-forces, and how aerospace medicine and test pilots work together to keep man functioning in the new environment.

Caidin, Martin 1963

FLYING

Holt, Rinehart and Winston $2.50

This book is a good reference for the study of the atmosphere, history of flight, jets and horizons unlimited. Useful in teaching the Aerospace Unit.

Clarke, Arthur C. 1959

THE CHALLENGE OF THE SPACE SHIP

Harpers $3.50

This book provides interesting outside reading for the above average student who is interested in space travel.

Davis, Clive E. 1961

MESSAGES FROM SPACE

Dodd, Mead $2.75

This is a good reference book to be used as resource material by the better student. It describes in layman's language how information is brought back from rockets and satellites.

Aerospace (continued)

Gottlieb, William P. 1959

JETS AND ROCKETS AND HOW THEY WORK

Garden City $2.95

This explains in simple language and with simple experiments the basic elements of rocket propulsion.

Haggerty, James J. 1962

SPACECRAFT

Scholastic Book Services $.50

This is the first of the "Vistas of Science" series. It discusses many of the problems of space travel and how NASA scientists and engineers are exploring them. Because of the 1961 publication date the presentation is rather simple, but well done. The section on "Ideas for Projects and Experiments" at the back of this paperback will be found helpful in planning effective learning experiences.

Kinney, William A. 1959

MEDICAL SCIENCE AND SPACE TRAVEL

Watts $3.95

Human reactions to solitude, silence and weightlessness, and investigations of possible harm from radiation, meteors and high temperatures. Easy to read and well written.

Rey, Lester Del 1959

SPACE FLIGHT

Golden Press $1.69

This is an easy, well illustrated book on problems involved in space travel from satellites to moon rockets. May be used as a reference book for slow groups.

lc
2/4/66

A TABULATED BIBLIOGRAPHY OF APPROVED TEXTBOOKS
Correlated to Junior High Science Content

9th Grade Topics 9th Grade Texts	Introduction to Science	Energy from Matter	Energy, Force and Motion	Electrical Energy	Wave Energy Light Sound	Nuclear Structure and Source of Energy	Aerospace
Basics							
Van Nostrand Obourn et al - '58 Science in Everyday Life	1X- 26	157-181 559-596	231-259 303-318	202-230 281-302	182-201 261-280	559-596	
Scott-Foresman Beauchamp et al - '58 Science Problems Three		52- 92 264-307 308-355	4- 51	104-163 244-263	164-217 218-243	93-103	
Holt Davis et al - '61 Science Three - Discovery and Progress		1- 25 58-121 416-467	388-415	326-387	264-301 302-325	468-495	234-263
Supplements							
Civil Air Patrol, Inc. Civil Air Patrol Pamphlets 2- Aircraft in Flight 3- Power for Aircraft 4- Airports, Airways and Electronics 5- Navigation & The Weather		3	2 5	4			
Rand-McNally Gilman and Van Houten - '57 General Science Today	2- 19	20- 57 270-305	58-113	380-443	306-347 348-379	444-483	
Holt Brooks and Tracy - '54 Modern Physical Science	1- 8	9- 21 112-157 216-357	158-215	426-501	398-425 378-397	502-519	
Allyn & Bacon Van Hooft - '56 Our Environment: How We Use and Control It	XV- 26	49-114 208-240	115-140 343-392	289-342 393-416	241-270 156-170	271-288	
Van Nostrand Hogg et al - '59 Physical Science		98-147 204-308	310-390	392-444	446-489 490-528	530-556	
Ginn Curtis and Mallinson - '58 Science in Daily Life	2- 14 536-546	86-134 516-535	281-318	319-359	173-204 496-515		
Lippincott Smith and Jones - '59 Using Modern Science	1- 19 106-121	35- 48 79-106	316-365 416-456	122-167 474-509	168-213 466-474		
Harcourt-Brace Brandwein et al - '60 You and Science	11- 51 649-656	314-349 454-474	434-453 502-531	475-501 561-579 586-624	580-585 547-560 532-546	274-314	185-203
Prentice-Hall Ames et al - '56 Science for Progress	4- 28 313-323	213-233 418-430 440-459	234-253	341-397 431-439	284-299 180-212 325-340	29- 57	

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A TABULATED BIBLIOGRAPHY OF APPROVED TEXTBOOKS
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9th Grade Topics 8th Grade Texts	Energy from Matter	Energy, Force and Motion	Electrical Energy	Wave Energy Light Sound	Nuclear Structure & Source of Energy	Aerospace
Basics						
Lippincott Smith and Jones - '59 Enjoying Modern Science	20- 38 57- 59	60- 97	38- 48	53- 57 48- 53		89- 94
Allyn & Bacon Smith - '60 Our Environment: How We Adapt Ourselves to It			292-367			
Holt, etc. Davis et al - '58 Science Two-Experiment and Discovery	1- 33	34- 93				
Supplements						
American Book Jacobson et al - '59 Broadening Worlds of Science		100-159 285-298 316-327	146-155 345-362	363-387 328-344		299-315
Heath Fletcher and Wolfe - '59 Earth Science						
Prentice-Hall Ames et al - '56 Science for Your Needs	208-231	126-173	174-207			
Scott Foresman Beauchamp et al - '57 Science Problems Two	4- 41 180-223	42- 85	256-291			
Harcourt Brace Brandwein et al - '60 You and Your Inheritance	186-232 233-253 288-358	288-311 385-418	254-272 359-378	273-287	166-185	459-478
Van Nostrand Namowitz and Stone - '60 Earth Science						

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1-29-62

A TABULATED BIBLIOGRAPHY OF APPROVED TEXTBOOKS
Correlated to Junior High Science Content

9th Grade Topics 7th Grade Texts	Energy from Matter	Energy, Force and Motion	Electrical Energy	Wave Energy Light Sound	Nuclear Structure & Source of Energy	Aerospace
Basics						
Lippincott Smith and Jones - '59 Exploring Modern Science	176-221					
Allyn-Bacon Smith - '60 Our Environment: Its Relation To Us	86-175	178-197	198-215			
Holt, etc. Davis et al - '59 Science One-Observation and Experiment	30- 65		186-243	120-153 154-185		
Supplements						
American Book Jacobson et al - '59 Adventures in Science			182-237			
Holt, etc. Fitzpatrick et al - '62 Living Things						
Prentice-Hall Ames et al - '56 Science in Today's World						
Scott Foresman Beauchamp et al - '57 Science Problems One	78-223		224-259			
Harcourt-Brace Brandwein et al - '60 You and Your World						

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MINNEAPOLIS PUBLIC SCHOOLS
Science Department

BASIC SCIENCE EDUCATION SERIES USEFUL IN JUNIOR HIGH SCHOOL SCIENCE
(Reading difficulty determined by Winnetka Scale)

GRADE SEVEN

Introduction to Science

The Scientist and His Tools - 4.5
Superstition or Science - 5.8

Plants

Adaptation to Environment - 5.1
An Aquarium - 2.7
Balance in Nature - 6.3
Dependent Plants - 3.7
Domesticated Plants - 6.6
Flowers, Fruits, Seeds - 3.8
The Garden and Its Friends - 3.7
Gardens Indoors - 3.3
Leaves - none*
Living Things - 2.9
Pebbles and Sea Shells - 3.0
Plant and Animal Partnerships - 3.3
Plant Factories - 3.9
The Plant World - 6.5
Plants Round the Year - 2.8
Seeds and Seed Travels - 3.3
Trees - 4.5
Useful Plants and Animals - 3.2
Watch Them Grow Up - 2.0

Water

Water - 4.1
Water Appears and Disappears - 2.6
Water Supply - 5.8

Animals (including human body)

Adaptation to Environment - 5.1
An Aquarium - 2.7
Animal Travels - 3.8
Animal World - 6.6
Animals and Their Young - 2.1
Animals of the Seashore - 3.8
Animals Round the Year - 3.3
Animals That Live Together - 1.9
Animals We Know - 4.2
Balance in Nature - 6.3
Birds - 3.8
Birds in the Big Woods - 2.1
Birds in Your Back Yard - none*
Domesticated Animals - 6.6
Fishes - 3.8
How Animals Get Food - 3.0
How We Are Built - 6.3
Insect Friends and Enemies - 5.6
The Insect Parade - 3.1
Insect Societies - 6.5
Insects and Their Ways - 4.8
Living Things - 2.9
Plant and Animal Partnerships - 3.3
Pebbles and Sea Shells - 3.0
The Pet Show - 3.2
Reptiles - 3.9
Saving Our Wildlife - 3.3
Six-Legged Neighbors - none*
Spiders - 3.4
Toads and Frogs - 3.2
Useful Plants and Animals - 3.2
Watch Them Grow Up - 2.0
You As a Machine - 5.4

Air

The Air About Us - 3.5
Fire - 4.1
Fire, Friend and Foe - 5.7
Our Ocean of Air - 4.1

*Vocabulary correlated with the Alice and Jerry Basic Readers.

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GRADE EIGHT

Introduction to Science

The Scientist and His Tools - 4.5
Superstition or Science - 5.8

Weather and Climate

Ask the Weatherman - 5.9
Clouds, Rain and Snow - 3.5
Pebbles and Sea Shells - 3.0
Water Appears and Disappears - 2.6
Ways of the Weather - 4.9

Geology

Animals of Yesterday - 4.5
The Earth A Great Storehouse - 4.9
The Earth's Changing Surface - 5.0
Life Through the Ages - 5.2
Pebbles and Sea Shells - 3.0
Soil - 5.1
Stories Read From the Rocks - 3.3

Astronomy

Beyond the Solar System - 5.4
The Earth's Nearest Neighbor - 4.1
How the Sun Helps Us - 2.4
The Sky Above Us - 3.5
The Sun and Its Family - 4.2

GRADE NINE

Introduction to Science

The Scientist and His Tools - 4.5
Superstition or Science - 5.8

Energy from Matter

Matter, Molecules and Atoms - 5.6
Water Appears and Disappears - 2.6
What Things are Made Of - 4.3

Energy, Force and Motion

Doing Work - 3.4
Gravity - 3.2
Machines - 3.2
Rockets and Missiles - 10**

Electrical Energy

Electricity - 4.1
Magnets - 2.7

Common Forms of Wave Energy

Heat - 5.1
Light - 4.5
Sound - 4.7
Thermometers, Heat and Cold - 3.8

Nuclear Structure and Sources of Energy

The Everyday Atom - 8.0

Aerospace

Satellites and Space Travel - 9**

**Reading difficulty determined by Dale-Chall formula.

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MINNEAPOLIS PUBLIC SCHOOLS
Board of Education Library

September 1962

SCIENCE BOOKS AVAILABLE IN PROFESSIONAL SECTION OF LIBRARY

ELEMENTARY

Arey, Charles K.
SCIENCE EXPERIENCES FOR ELEMENTARY SCHOOLS, Rev. Ed.
Teachers College, 1961. 375.5 A

Association for Childhood Education
THIS IS SCIENCE
H. S. Zim, 1945. 375.5 A

Besser, Marianne
GROWING UP WITH SCIENCE
McGraw, 1960. 375.5 B

Blough, G. W., and Huggett, A. J.
ELEMENTARY SCHOOL SCIENCE AND HOW TO TEACH IT, Rev. Ed.
Dryden, 1958. 375.5 B

Blough, Glenn O., ed.
IT'S TIME FOR BETTER ELEMENTARY SCHOOL SCIENCE: REPORT OF AN ASSOCIATION CONFERENCE SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION
National Science Teachers Association, 1958. 375.5 B

Blough, Glenn O.
MAKING AND USING CLASSROOM SCIENCE MATERIALS IN THE ELEMENTARY SCHOOL
Dryden, 1954. 375.5 B

Blough, Glenn O. and Huggett, A. J.
METHODS AND ACTIVITIES IN ELEMENTARY SCHOOL SCIENCE
Dryden, 1951. 375.5 B

Brandwein, Paul F.
ELEMENTS IN A STRATEGY FOR TEACHING SCIENCE IN THE ELEMENTARY SCHOOL
(Combined with Schwab, THE TEACHING OF SCIENCE AS ENQUIRY)
Harvard Univ. Press, 1962. 375.5 S

Burnett, R. W.
TEACHING SCIENCE IN THE ELEMENTARY SCHOOL
Rinehart, 1953. 375.5 B

Craig, Gerald S.
SCIENCE FOR THE ELEMENTARY-SCHOOL TEACHER
Ginn, 1958. 375.5 C

Craig, Gerald S.
SCIENCE IN CHILDHOOD EDUCATION
Teachers College, 1944. 375.5 C

Craig, Gerald S.
SCIENCE IN THE ELEMENTARY SCHOOLS: WHAT RESEARCH SAYS TO THE TEACHER #12
Department of Classroom Teachers, N.E.A., 1957. 375.5 C

Dunfee, Ma[illegible]
ELEMENTARY SCHOOL SCIENCE: RESEARCH, THEORY AND PRACTICE
Association for Supervision and Curriculum Development, N.E.A., 1957
375.5 D

Freeman, Kenneth
HELPING CHILDREN UNDERSTAND SCIENCE
Winston, 1954. 375.5 F

Fuller, Elizabeth M.
SPRINGBOARD TO SCIENCE: SUGGESTED EXPERIENCES AND EXPERIMENTS TO ENCOURAGE CHILDREN TO DEVELOP AN EARLY INTEREST IN SCIENCE
Denison, 1959. 375.5 F

Greenlee, Julian M.
BETTER TEACHING THROUGH ELEMENTARY SCIENCE
Brown, 1954. 375.5 G

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TEACHING SCIENCE TO CHILDREN
Brown, 1951. 375.5 G

Hale, Mason E., Jr.
LICHEN HANDBOOK: A GUIDE TO THE LICHENS OF EASTERN NORTH AMERICA
Smithsonian Institution, 1961. 589 H (Also listed with senior high)

Heiss, Elwood D.
MODERN SCIENCE TEACHING
Macmillan, 1950. 375.5 H (Also listed with junior and senior high)

Hochman, V. and Greenwald, M.
SCIENCE EXPERIENCES IN EARLY CHILDHOOD EDUCATION
69 Bank Street Publications, 1953. 375.5 H

Hubler, Clark
WORKING WITH CHILDREN IN SCIENCE
Houghton Mifflin, 1957. 375.5 H

Hungerford, Harold R.
TEACHING ELEMENTARY SCIENCE WITHOUT A SUPERVISOR
Walch, 1959. 375.5 H

Jacobson, Willard J. and Tannenbaum, Harold E.
MODERN ELEMENTARY SCHOOL SCIENCE: A RECOMMENDED SEQUENCE
Teachers College, 1961. 375.5 S

Manufacturing Chemists' Association
MATTER, ENERGY AND CHANGE: EXPLORATIONS IN CHEMISTRY FOR ELEMENTARY SCHOOL CHILDREN
1960. 375.5 M

Minnesota Department of Education
GUIDE FOR INSTRUCTION IN SCIENCE AND CONSERVATION, ELEMENTARY SCHOOL, GRADES 1-8, Curriculum Bulletin #7
1951. 375.5 M (Also listed with junior high)

Navarra, John G.
SCIENCE TODAY FOR THE ELEMENTARY SCHOOL TEACHER
Row Peterson, 1960. 375.5 N

Nelson, Leslie Weldemar
SCIENCE ACTIVITIES FOR ELEMENTARY CHILDREN
Brown, 1952. 375.5 N

Noll, Victor H.
TEACHING OF SCIENCE IN ELEMENTARY AND SECONDARY SCHOOLS
Longmans, 1939. 375.5 N (Also listed with junior and senior high)

Piltz, Albert
SCIENCE EQUIPMENT AND MATERIALS FOR ELEMENTARY SCHOOLS
U. S. Dept. of Health, Education and Welfare, OE-29029, No. 28, 1961.
375.5 U

Schwab, Joseph J.
THE TEACHING OF SCIENCE AS ENQUIRY (Combined with Brandwein, ELEMENTS IN A STRATEGY FOR TEACHING SCIENCE IN THE ELEMENTARY SCHOOL)
Harvard University Press, 1962. 375.5 S

Sheckles, Mary
BUILDING CHILDREN'S SCIENCE CONCEPTS: EXPERIENCES WITH ROCKS, SOIL, AIR, AND WATER. PRACTICAL SUGGESTIONS FOR TEACHING #15
Teachers College, 1958. 375.5 S

Slavson, S. R. and Speer, R. K.
SCIENCE IN THE NEW EDUCATION AS APPLIED TO THE ELEMENTARY SCHOOL
Prentice-Hall, 1934. 375.5 S

Stevens, Bertha
TEACHING SCIENCE IN THE ELEMENTARY SCHOOL
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Tannenbaum, H. E. and Stillman, N.
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Science Department
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For discussion purposes only

A PARTIAL LISTING OF PRESENTLY OWNED

SCIENCE MOTION PICTURE FILMS

for
Grade Nine

Correlated to the Major Topics as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
4-14-1966

For discussion purposes only

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The annotations for films found on the following pages were obtained in most cases from the Library of Congress cards. Some annotations were secured from other sources such as the Educational Film Guide and producers' catalogs.

Introduction to Science

Name and Description of Film	Other Grade Placements	Remarks
1. Galileo's Laws of Falling Bodies * EBF, 1953; 6 min., black & white Dramatizes the events which led to Galileo's discovery of some of the fundamental laws pertaining to falling bodies and discusses his pioneer work in physical science. Slow motion and stop frame techniques are used to demonstrate Galileo's concepts concerning speeds of falling objects.	Gr. 9 - Gr. 11 - **	Also listed Energy, Force and Motion
2. The Mathematician and the River ** Educ. Test Serv., 1960; 19 min., color Discusses the role of mathematics in predicting and controlling the flow of the Ohio-Mississippi-Missouri river system. Shows the concrete scale model constructed by the U. S. Army Corps of Engineers at Jackson, Miss. Professor Eugene Isaacson of the Institute of Mathematical Sciences of New York University describes a mathematical kind of model, explaining that for each ten miles of the river two equations are written and the many resulting equations are combined by modern computers to provide the model of the entire river system.	Gr. 11 - **	With prep.
3. Isaac Newton * Coronet, 1959; 13½ min. Depicts the life of Newton; his intellectual growth, and his discoveries in mathematics and physical science. Special attention is given to the binomial theorem, the differential and integral calculus, the nature of light, and his formulation of the Law of Gravitation; his connection with earlier and contemporary thinkers is also discussed.	Gr. 11 - **	

* Good
** Excellent

Introduction to Science (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Our Friend the Atom ** Walt Disney, 1957; 50 min., color Traces the history of man's efforts to solve the mysteries of the atom from the first guesses of Democritus to the latest successes of modern scientists; discusses the significance of the Einstein equation, control of nuclear fission, implications of atomic developments for transportation, medicine, agriculture and electric power; and the responsibilities imposed on society by the new energy source. Includes animated sequences.	Gr. 9 - Gr. 11 - **	Also listed Nuclear Structure and Sources of Energy
5. Preface to Physics ** EBF, 1955; 60 min., color This film has exceptional value in providing orientation for beginners in physics or those considering a beginning physics course. Opening at historic Mt. Vernon, the film compares the progress made in science before Washington's time with the tremendous advances since then. The important role of physics is identified and significant divisions of physics are indicated--mechanics, heat, sound, light, magnetism and electricity.		
6. Speed of Light * EBF, 1955; 20 min., black & white Reviews the numerous historic attempts to measure the speed of light and describes more recent experiments that led to the determination of C; dramatizes Galileo's experiments, Roemer's study of Jupiter's satellites and his determination of C. Fizeau's toothed wheel experiments, and finally the mirror methods used by Foucault and Michelson. Applies the concept of C to modern physics and develops it as a universal stick.	Gr. 9 - Gr. 11 - **	Also listed Common Forms of Wave Energy

* Good
** Excellent

Introduction to Science (continued)

Name and Description of Film	Other Grade Placements	Remarks
7. Thinking Machines ** Educ. Test. Serv., 1960; 19 min., color Shows demonstrations of some recent machine developments and compares these with the performance of the human brain. Mathematician Claude E. Shannon demonstrates his artificial mouse in an electronic maze, Alex Bernstein and his collaborators at International Business Machines demonstrate a digital computer to play chess, and Leon Harmon demonstrates a pattern recognizer which is able to determine whether a figure is a circle, a triangle, a square, or a pentagon.	Gr. 11 - *	
8. Understanding Matter and Energy ** Int'l Film Bureau, 1962; 18 min., color In a fascinating film technique, the "conversation" a boy has with a narrator leads to a thorough demonstration of the physical properties of matter in its solid, liquid or gaseous state. Animation clarifies the molecular action of matter while it is a solid, liquid, or gas. The concept that matter may be transformed into energy and that these sources of energy, heat, chemical, mechanical, light, electrical - are utilized to serve man -- is also shown.	Gr. 9 - Gr. 5 - * Gr. 6 - **	Also listed Energy from Matter

* Good
** Excellent

Energy from matter

Name and Description of Film	Other Grade Placements	Remarks
1. Archimedes' Principle ** EBF, 1953; 6 min., black & white Dramatizes the events which led to Archimedes' discovery of the law that governs the flotation of bodies in water and other liquids. Shows experiments in a modern physics laboratory which prove Archimedes' principle. Includes an experiment which is developed through the use of the Archimedes balance.		
2. The Atom and Medicine ** EBF, 1952; 12 min., black & white Shows various uses of radioisotopes in hospitals, doctor's offices, and research laboratories; discusses the potentialities of atomic energy in the field of medicine.	Gr. 10 - *	
3. Catalysis * EBF, 1937; 10 min., black & white Presents a study of catalysis as the fourth factor in the velocity of chemical reactions. Explains how catalysts may function by absorbing molecules, activating molecules, forming an intermediate compound, or starting a chain reaction. Illustrates application of negative catalysts in the manufacture of rubber and anti-knock gasoline. Calls attention to the reaction of catalysis to plant and animal life.	Gr. 12 - **	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Combustion ** John Sutherland Prod., 1958; 15 min., color Uses the fire triangle to visualize conditions necessary for combustion, to illustrate the need for all parts of the triangle to be present, and to show factors involving the rate of combustion and spontaneous ignition. Shows the extent and the results of partial and complete combustion, and describes the industrial uses of combustion.	Gr. 12 - **	
5. Evidence for Molecules and Atoms ** EBF, 1961; 19 min., color Uses simple experiments to reveal that even though we cannot see them, atoms and molecules exist. The experiments also show that circumstantial evidence is very valuable in scientific research.	Gr. 6 - **	
6. Explaining Matter: Atoms and Molecules ** EBF, 1956; 14 min. Presents the atom as the building block of matter and shows the interrelationships between atoms, molecules, elements, compounds, and mixtures. Indicates that the number of different substances which can be made from the more than one hundred types of atoms is infinite. Explains how atoms are combined to form molecules and shows how these molecules may exist separately or in combination with others, to form elements or compounds.	Gr. 6 - *	Hard vocab.

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
7. Explaining Matter: Chemical Change ** EBF, 1960; 12 min., color Describes chemical change as part of everyday life, explaining that such ordinary things as fire, growing plants, and growing bodies depend on complex chemical changes. Uses animation, laboratory demonstrations, and molecular models to visualize difficult concepts, showing how the atoms from the molecules of two or more materials recombine with each other to form molecules of entirely different materials, how chemical changes can produce energy in the human body through the process of digestion, and how they make food in green plants through the process of photosynthesis.	Gr. 6 - **	
8. Fire Science * Churchill-Wexler, 1960; 15 min., color An introduction to the chemistry of combustion. Highlights historical uses of fire and the importance of fire in today's civilization. Uses animation to visualize the molecular action of a burning fuel whose carbon and hydrogen atoms combine with oxygen to form carbon dioxide and water, releasing energy in the form of heat and light. Experiments explain the concepts of fuel, oxidation, kindling temperature, and spontaneous combustion.	Gr. 5 - ** Gr. 6 - **	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
9. Gas for Home and Industry * EBF, 1949; 17 min., black & white Explains the role of fuel gas as a source of energy. Describes the production of various types of manufactured gas, using natural photography and animated drawings. Shows how natural gas is obtained from wells and distributed through pipelines to population centers. Discusses the importance of gas conservation and suggests future technological developments in gas manufacture.		
10. The Halogens ** Coronet, 1947; 11 min. Analyzes in a laboratory demonstration the physcial and mechanical properties of fluorine, chlorine, bromine, and iodine, both free and in compound. Reduces the speed of experiments through slow-motion cameras so that every detail is shown.	Gr. 12 - *	
11. Iron--Product of the Blast Furnace * Academy Films, 1951; 11 min. Shows how iron ore, coke, and limestone, are handled at a blast furnace preparatory to charging the furnace; the making of coke from coal; and through an animated diagram, demonstrates what happens inside the furnace. Pictures the molten iron being removed from the bottom of the furnace, put into a torpedo ladle car, and taken to the open hearth steel furnaces.	Gr. 4 - **	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
12. Learning About Heat * EBF, 1958; 8 min., black & white Identifies and describes the characteristics of heat. Points out that hands get cold because heat, not cold, is transferred. Uses animation to explain expansion and contraction according to the theory of molecular activity as a solid is changed to a liquid and then to a gas. Discusses the three methods of heat transference and ends with a review of the concepts.	Gr. 9 - Gr. 5 - **	Also listed Common Forms of Wave Energy
13. Matter and Energy * Coronet, 1947; 11 min. Explains that everything in the universe is either matter or energy. Visualizes, through the sound and motion of actual examples, matter and its different forms, physical and chemical change, and the laws of conservation of matter and energy.	Gr. 11 - **	
14. Metals and Non-metals ** Coronet, 1949; 11 min. Discusses the physical characteristics and reactions which distinguish metals from non-metals; demonstrates that metals are lenders of electrons and non-metals are borrowers of electrons; explains the nature of alloys and metallic compounds.	Gr. 11 - ** Gr. 12 - *	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
15. Molecular Theory of Matter ** EBF, 1965; 11 min., color Presents evidence of molecular activity in gases, liquids and solids in support of the molecular-kinetic theory of matter. Presents the theory first as an hypothesis, then uses demonstrations to support the hypothesis and animated sequences to explain the mechanism at work. Explains the Brownian movement, the volume - pressure and temperature - pressure relationship, and the change of state in terms of molecular activity. Correlates with Chem Study curriculum.		
16. The Nature of Energy ** Coronet, 1949; 11 min. Clarifies the scientific concept of energy by showing the relationships of atomic energy to the other forms of energy in order to have a better understanding of electricity, sound, light and heat.	Gr. 11 - *	Easy film
17. Osmosis ** EBF, 1958; 14 min. The process of osmosis as it applies to plant growth. Animation and time-lapse photography demonstrate movement of molecules, and diffusion of gases and liquids. Shows how the process of osmosis depends upon nature of the membrane, temperature of the solution, and concentration of solutions. Experiments with living plants.	Gr. 7 - ** Gr. 10 - **	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
18. Oxygen ** Coronet, 1947; 11 min. Through laboratory experiments, develops the characteristics, uses, and significance to man of oxygen and its compounds. Surveys the preparation, properties, and characteristics of this element, and explains electrolysis, oxidation, forms of oxygen, etc.	Gr. 6 - * Gr. 12 - *	Needs prep. Early 12th
19. Properties of Water ** Coronet, 1947; 11 min. Answers questions concerning the properties and characteristics of water. Demonstrates experiments with electrolysis, boiling and freezing points, distillation, solutions, crystallization, filtration, and pressure cookery.		
20. Sulphur and Its Compounds * Coronet, 1945; 11 min. Outlines the part played by sulphur in modern industry and mentions development in the element's history. Illustrates the properties of sulphur and its compounds, and includes an explanation of modern sulphur mining.	Gr. 12 - **	

* Good
** Excellent

Energy from matter (continued)

Name and Description of Film	Other Grade Placements	Remarks
21. Understanding Matter and Energy ** Int'l Film Bureau, 1962; 18 min., color In a fascinating film technique, the "conversation" a boy has with a narrator leads to a thorough demonstration of the physical properties of matter in its solid, liquid, or gaseous state. Animation clarifies the molecular action of matter while it is a solid, liquid, or gas. The concept that matter may be transformed into energy and that these sources of energy, heat, chemical, mechanical, light, electrical - are utilized to serve man -- is also shown.	Gr. 5 - * Gr. 6 - ** Gr. 9 -	Also listed in Introduction

* Good
** Excellent

Energy, force and motion

Name and Description of Film	Other Grade Placements	Remarks
1. The ABC of the Automobile Engine ** Gen. Motors, 1948; 18 min., color Combines cartoon and technical animation to illustrate the component parts of an automobile engine and how they operate. Three basic ingredients (air, fuel, and ignition) that make an engine operate are personified as animated cartoon characters who are shown performing their individual jobs in making the engine run. Explains the function of the carburetor, piston, piston rings and pins, connecting rods, crankshaft, valve mechanism, ignition, cooling and lubricating systems, etc.	Gr. 11 -	No eval. yet
2. The ABC of Internal Combustion ** Gen. Motors, 1948; 13 min., color Shows how air, fuel, and ignition work together to create power in the internal combustion engine. Demonstrates how a piston connecting rod, and crankshaft can harness power; illustrates the four-stroke cycle, the valve operation, carburetion, and ignition timing.	Gr. 11 -	No eval. yet
3. Around the Corner * Jam Handy, 1937; 11 min., black & white Discusses the differential, explaining how it works. Shows how wheels on the same vehicle travel at different speeds.		

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
4. Atmospheric Pressure * EBF, 1926; 12 min., black & white Illustrations of unbalanced air pressure, including the Madgeburg hemisphere demonstration. Shows atmospheric variations in pressure between valley and hilltop and between land and water.	Gr. 7 - **	Adv.
5. Energy and Work ** EBF, 1961; 11 min., color Uses simple experiments and visual experiences to explain the basic concept that energy is neither created nor destroyed, but simply changed from one form to another. Illustrates ways in which energy can be stored, ways in which potential energy can be changed into kinetic energy, and how kinetic energy can be changed into mechanical energy for the purpose of doing work.	Gr. 6 - **	
6. The Force of Gravity * McGraw-Hill, 1961; 27 min., color Understanding of present day geophysical research and to increase man's understanding of the force of gravity.	Gr. 6 - **	Needs Prep.

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
7. Forces ** EBF, 1961; 13 min. Presents a visual explanation of the scientific concept of forces--what they are, what they can do, and how they are measured. A series of demonstrations show that forces can sometimes change the shape of an object, that they can speed up or slow down a moving object, and that a continually applied force can make an object move in a curved path. Illustrates the effects of electrical forces, magnetic forces, and the force of gravity.	Gr. 6 - **	
8. Fuels--Their Nature and Use ** EBF, 1958; 11 min. Describes the principal kinds of fuels used in homes and industry; traces the source of most conventional fuels to the sun; and explains the history of fuels. Uses animation to explain how heat is transferred to mechanical energy in steam, gasoline, and diesel engines.	Gr. 5 - ** Gr. 7 - ** Gr. 11 - *	
9. Galileo's Laws of Falling Bodies * EBF, 1953; 6 min., black & white Dramatizes the events which led to Galileo's discovery of some of the fundamental laws pertaining to falling bodies and discusses his pioneer work in physical science. Slow motion and stop frame techniques are used to demonstrate Galileo's concepts concerning speeds of falling objects.	Gr. 9 -	Also listed in Introduction

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
10. Gravity **	Gr. 5 - **	
	Gr. 6 - **	
Coronet, 1950; 11 min.	Gr. 8 - **	For slow students
Through a variety of everyday examples explains the force of gravity. Shows attraction in relation to mass and distance, and the effect of gravity on our solar system. Demonstrates and explains mutual attraction between all bodies.		
11. Gravity--How it Affects Us **	Gr. 2 - **	Advanced
	Gr. 3 - **	
EBF, 1960; 14 min., black & white	Gr. 6 - **	
Illustrates gravity's importance by showing some of the things that gravity does; its action upon our daily activities, its effects on our earth, and how it would affect a human being on an imaginary trip through outer space. Includes sequences on the experiments of Galileo and Isaac Newton.		
12. Laws of Motion *	Gr. 11 - *	
EBF, 1952; 13 min., color		
Simple experiments explain the theory of Newton's three laws of motion--the phenomena of momentum and inertia, the concept of acceleration, and the theory of reciprocal attraction of all bodies. Shows everyday applications of these laws.		

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
13. Magnetic, Electric, and Gravitational Fields** EBF, 1961; 11 min. Uses animated drawings with live-action scenes to define the characteristics of fields and to illustrate their practical applications. Shows the effects of a magnetic field on a compass needle, of the earth's gravitational field on the moon's orbit, and of electric fields on materials such as wood, glass, and steel.	Gr. 9 - Gr. 4 - ** Gr. 5 - **	Also listed Electrical Energy
14. Molecular Theory of Matter ** EBF, 1932; 11 min., black & white Discusses the theory that all matter consists of molecules in motion. Portrays molecular aspects of the diffusion of gases in air and vacuum, condensation of steam, evaporation of liquids, and transformation of liquids into solids. Explains force exerted by molecules in motion by using machine gun analogy. Microscopic photography demonstrates Brownian movement.		
15. Moving Things on Land ** Churchill-Wexler, 1959; 11 min., color Jim and Bobby try to move a heavy box of comic books to Bobby's house. When they try to drag it, the uses and shortcomings of friction are clearly demonstrated. The boys solve their problem and overcome friction by the use of sled runners and powdered soap to smooth the road, rollers, wooden wheels, metal wheels and roller bearing wheels.	Gr. 6 - **	

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
16. Simple Machines: Inclined Planes ** Coronet, 1954; 6 min., black & white Shows how an inclined plane or slope facilitates the moving of heavy objects. Demonstrates the everyday use of the inclined plane and explains that such simple machines as screws and wedges are used when it is desirable to trade distance for force.	Gr. 2 - ** Gr. 6 - ** Gr. 11 -	 No eval. yet
17. Simple Machines: Levers ** Coronet, 1954; 6 min. Describes combinations of levers which are found in complex machines, playground equipment, and many household tools. Models of first, second, and third class levers are shown and explained as is the fact that power may be increased when distance is traded for force.	Gr. 6 - **	
18. Simple Machines: Pulleys ** Coronet, 1954; 6 min. Shows how pulleys make possible the lifting of heavy loads with a minimum of effort. Explains that movable pulleys multiply force and fixed pulleys change the direction of a force.	Gr. 6 - **	

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
19. Simple Machines: the Inclined Plane Family * EBF, 1960; 11 min. Explains the operation of the inclined plane by following a young boy who discovers, through a series of simple experiments, how an inclined plane can make work easier. Explains the concept of work through the use of animated drawings. Also describes other machines of the inclined plane family--the wedge and the screw.	Gr. 6 - **	
20. Simple Machines: Wheels and Axles * Coronet, 1954; 6 min. The functions of rolling wheels and working wheels are compared and described on a bicycle and automobile. The forces exerted by a bicycle chain, rear axle, and rear wheel are shown with a spring balance. Explains the mechanical advantage of combining these forces with bicycle pedals and sprocket wheels and how pedals, sprockets, and wheels multiply force in a rider's legs five times. A second example of belts and gears also illustrates the trading of force for distance.	Gr. 6 - **	
21. Spinning Levers * Jam Handy, 1937; 11 min., black & white Shows how the principle of the lever is used in an automobile through the use of gear wheels. The workings of the gears and gear shift are explained.	Gr. 11 -	No eval. yet

* Good
** Excellent

Energy, force and motion (continued)

Name and Description of Film	Other Grade Placements	Remarks
22. Thinking Machines ** Educ. Test. Serv., 1960; 19 min., color Shows demonstrations of some recent machine developments and compares these with the performance of the human brain. Mathematician Claude E. Shannon demonstrates his artificial mouse in an electronic maze, Alex Bernstein and his collaborators at International Business Machines demonstrate a digital computer to play chess, and Leon Harmon demonstrates a pattern recognizer which is able to determine whether a figure is a circle, a triangle, a square, or a pentagon.	Gr. 9 - Gr. 11 - *	Also listed in Introduction
23. What is Uniform Motion ** EBF, 1961; 13 min., color The two essentials of uniform motion are illustrated. The cause of friction is demonstrated. A frictionless air puck is made and used. The path of projectiles is examined to show that they are not illustrations of uniform motion.	Gr. 6 - **	

* Good
** Excellent

SCIENCE MOTION PICTURE FILMS - Grade Nine
(Addendum)

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Energy, force and motion

Name and Description of Film	Other Grade Placements	Remarks
Friction ** MGH, 1962; 10 min., color Introduces friction as a restraining force, and explains the various ways in which we try to reduce friction or try to increase it to serve our everyday needs.	Gr. 6 - **	

* Good
** Excellent
5/23/67

Electrical energy

Name and Description of Film	Other Grade Placements	Remarks
1. Amperes, Volts, and Ohms ** U. S. Office of Educa., 1947; 8 min., b&w Explains the meaning, relationship, and measurement of amperes, volts, and ohms.	Gr. 11 -	No eval. yet
2. Bell Solar Battery * N.W. Bell Tele., 1956; 12 min., color Shows how the Bell solar battery is made and how it works, and its use in electronics and communications. Shows research in the Bell Telephone Laboratories leading to this invention.	Gr. 11 - **	
3. Capacitance ** U. S. Govt., 1943; 31 min., black & white Demonstrates the flow of electrons through a circuit and shows the changing and discharging of condensers. The variations of a charge on a condenser in relation to time and the behavior of capacitance with alternating current are discussed.	Gr. 11 - **	
4. Electricity Production ** I N U, 1963; 15 min., color Develops the concept of energy conservation in explaining the basic principles of the generator, storage cell, and primary cell. Shows applications of less well known sources of electrical energy as photo-cells, solar cells, thermo-couples, and fuel cells.		

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
5. Electricity: Static Electricity ** I N U, 1963; 11 min., color Traces the development of man's understanding of static electricity. Shows various ways it is used. Reviews basic laws of electrical charges. Develops an explanation of lightning and how it can be controlled. Depicts harmful effects of static electricity. Illustrates useful applications.	Gr. 5 - **	
6. Electrodynamics ** EBF, 1936; 11 min., black & white Reveals that moving electric charges creates a magnetic field and that moving magnets create an electric current. Explains Galvani's discovery of electric current, magnetic properties of a current-carrying wire and of an electric coil. Describes Rowland's experiment, recalescence, and electromagnetic induction as it functions in generators and transformers. Includes animation.	Gr. 9 - Gr. 5 - * Gr. 11 - **	As introduction
7. Electrostatics * EBF, 1950; 11 min., black & white Shows the nature of repulsive and attractive forces between bodies charged by contract under different conditions. Demonstrates techniques of charging by induction, and the part played by conductors and insulators, and compares the use of two measuring devices, the electroscope and the electrometer. Depicts the development of atmospheric conditions leading to the discharge of lightning in a thunderstorm and explains the protective value of lightning rods.	Gr. 11 - **	

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
8. The Electron: An Introduction * U. S. Off. of Educ., 1944; 16 min., b&w Nature of electrons; electron flow in solid conductors; electromotive force; types and control of electron flow; electron flow and magnetic fields; and induced electron flow.	Gr. 11 - **	
9. Electrons * EBF, 1937; 11 min., black & white Through animated drawings and photography explains the hypothesis that electricity consists of unit elementary charges. Demonstrates the conduction of electricity through solutions, gases, and vacuum; Faraday's laws; movement of charges in vacuum tubes; operation of photoelectric cells; and reproduction of sound on film.	Gr. 11 - **	
10. Exploring Electromagnetic Energy ** Film Assoc. of Calif., 1961; 13 min., color Discusses electromagnetic energy and describes some of the ways in which it is used. Explains that radio waves, infrared, visible light, ultraviolet, X-rays, and gamma rays are all members of the same family.	Gr. 5 - ** Gr. 11 - *	
11. The Flow of Electricity ** Young America, 1946; 10 min., black & white Two children learn about the factors which affect the flow of electricity through a simple electrical circuit. Introduces the electron theory, and shows the application of a simple circuit in a home situation.	Gr. 5 - **	

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
12. How Electricity is Produced * Pat Dowling, 1960; 11 min., color Explains that electricity is produced in three ways--by friction, by chemical action, and by magnetic action. Depicts Faraday discovering the principle of an induced current and demonstrates with a small magneto generator the principle of current electricity. Uses photographs of a hydro-electric plant to show how mechanical energy is converted into electrical energy, using the principle discovered by Faraday.	Gr. 5 - **	
13. How to Produce Electric Current With Magnets** EBF, 1961; 10 min., color The magnetic effects of an electric current are demonstrated. Electromagnets are made and what they can do is illustrated. A coil of copper wire is connected to an electric meter and a magnet is brought near. The magneto on a motor scooter is explained. The transition is made from permanent to temporary magnets to generate electric current as at the Hoover Dam Powerhouse.	Gr. 5 - **	
14. Introduction to Electricity * Coronet, 1948; 11 min. Introduces the basic principles of electricity. Investigates, through the interests of two students, static and current electricity, showing how the natural repulsion of electrons makes electricity with chemicals and with magnetic lines of force.	Gr. 9 - Gr. 5 - **	For slower group

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
15. Just Imagine * Bell Tele. Co., 1947; 10 min., black & white Shows the wide variety of raw materials needed to make the 433 separate parts of the modern telephone.		
16. Learning About Electric Current * EBF, 1958; 8 min., black & white Describes characteristics, uses and dangers of electric current. Circuits, conductors, insulators, fuses, and switches are explained both in animation and in simple demonstration and the electricity used in the home is traced back to the generators in power plant.	Gr. 9 - Gr. 5 - **	For slower group
17. Magnetic, Electric, and Gravitational Fields** EBF, 1961; 11 min. Uses animated drawings with live-action scenes to define the characteristics of fields and to illustrate their practical applications. Shows the effects of a magnetic field on a compass needle, on the earth's gravitational field on the moon's orbit, and of electric fields on materials such as wood, glass and steel.	Gr. 4 - ** Gr. 5 - ** Gr. 9 -	Also listed Energy, Force and Motion
18. Making Electricity ** EBF, 1949; 11 min., black & white Demonstrates how electricity is made by moving a coil of wire through the field of a magnet. Explains how a small, hand-powered generator is constructed and how it operates; illustrates how the same principle applies in generating electricity at a large hydroelectric plant; and reveals how electricity is carried over power lines to the consumer.	Gr. 3 - ** Gr. 5 - **	

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
19. Primary Cell * EBF, 1944; 11 min., black & white Explains dry cell operation in terms of electron action. Through animated drawings and natural photography demonstrates ionization of an electrolyte, electron flow, action at electrodes, polarization, and function of the depolarizer. Reveals operating characteristics and uses of a single cell and of cells connected as a battery in series and in parallel.		
20. Radio Antennas: Creation and Behavior of Radio Waves ** U.S. Off. of Educa., 1943; 12 min., b&w Explains electric and magnetic fields, generation of electromagnetic waves, behavior of radio waves in space, ground wave, reflection and refraction, the ionosphere, and causes of fading.	Gr. 11 - *	
21. Series and Parallel Circuits ** EBF, 1944; 11 min., black & white Clarifies the relationships between resistance, current, and electromotive force in series circuits and in parallel circuits, and demonstrates the advantages and disadvantages of both types of circuits. Describes a simple series-parallel combination and offers examples.	Gr. 5 - *	Mature

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
22. Vacuum Tubes ** EBF, 1943; 11 min., black & white Explains by animated drawings, the operation of a radio vacuum tube in terms of its filament, plate, and grid circuits. Illustrates three functions of the vacuum tube in the radio; how it serves as an amplifier to operate the loud speaker, as a rectifier in detection, and as an oscillator to generate the carrier waves.	Gr. 11 - *	
23. Voltaic Cell, Dry Cell, and Storage Battery * U.S. Off. of Educa., 1943; 18 min., b&w Explains the principles of a voltaic cell, a dry cell, and a storage battery.		
24. What is Electric Current? ** EBF, 1962; 13 min., color Although you can't see the flow of electric current as you can see the flow of running water, there is circumstantial evidence that electricity behaves somewhat like water in a pipe. To demonstrate effects of electric current, the film uses a simplified circuit connecting an automobile battery with headlights, a horn, and a starter motor. Experiments show that electricity flows only when it has a complete pathway or circuit, and that it can flow in either direction in a circuit.	Gr. 5 - **	

* Good
** Excellent

Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
25. What is Electricity? ** EBF, 1953; 13 min., black & white Presents electrostatic experiments of Du Fay, Benjamin Franklin, and Volta. Provides a visual account of electromagnetism by recreating the experiments of Oersted and Faraday which led to the development of motors and generators. Discusses the nature of electricity and its correlation with atomic theory. Includes a series of diagrams which explain the organization of atoms and the movement of electrons which results in the flow of electricity in metals.	Gr. 11 - **	

* Good
** Excellent

SCIENCE MOTION PICTURE FILMS - Grade Nine
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Electrical energy

Name and Description of Film	Other Grade Placements	Remarks
Electricity: Distribution ** Indiana University, 1962; 17 min., color Develops basic concepts of electrical distribution, both cross-country and within the home. Complete distribution system is explained, with demonstrations of "line loss" and the use of fuses for overload protection. Reviews parallel and series circuitry, using questions.	Gr. 11 - *	
Electricity: Measurement ** Indiana University, 1962; 10 min., color Utilizes simple mock-ups to develop concepts of electrical pressure, current, resistance, Ohm's Law and electrical power. Measurement is demonstrated with a battery and lamp circuit. Ohm's Law is used to work the formula Volts = Ampheres x Ohms. Use of the kilowatt-hour meter as a recorder of electrical power is demonstrated.	Gr. 11 - **	
Electrons and Electronics: An Introduction ** Coronet, 1962; 11 min., b/w This film clearly explains how such electronic devices as vacuum tubes and transistors work and how they are put to use in the fields of communications, transportation, medicine fields and industry. A visit to a broadcasting station shows us what part electronics plays in bringing us radio and television.	Gr. 11 - **	

* Good
** Excellent
5/23/67

SCIENCE MOTION PICTURE FILMS - Grade Nine
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Electrical energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
Nike ** NW Bell, 1960; 7 min., b/w Actual scenes taken at the White Sands Proving Ground show NIKE tracking and destroying a "hostile" plane. The narration reveals why Bell Telephone Laboratories helped develop the Army's guided missile system. The electric brain that is the heart of NIKE is compared with one that searches out a distant number when the dial telephone mechanism is operated.	Gr. 11 - **	

* Good
** Excellent
5/23/67

Common forms of wave energy

Name and Description of Film	Other Grade Placements	Remarks
1. Bottle of Magic * Wilding Picture Prod., 14 min., black & white Shows the development, manufacture, and present day uses of the electron tube. Includes scenes showing the earliest development and uses of the tube.		
2. Color and Light: An Introduction * Coronet, 1962; 11 min., color Characteristics of color formation by different kinds of light are demonstrated in a variety of everyday situations. Theatrical spotlights are used to show the effect of different kinds of light with opaque, transparent, and translucent objects.	Gr. 6 - *	
3. The Diode: Principles and Applications ** U.S. Off. of Educ., 1945; 17 min., b&w Principles of electron flow across a gap, basic features of the diode tube; control of electron flow in the tube; photoelectric cells; X-ray tubes; and the diode as a rectifier.	Gr. 9 - Gr. 11 - **	Full year 9th Sci.
4. Discovering Where Sounds Travel ** Academy Films, 1964; 11 min., color Provides experiences in observing basic facts about the transmission of sound in air, water, and metal. Demonstrates that sound cannot travel in a vacuum. Shows how sound travels readily through water. Depicts that sound travels fifteen times faster through metal than through air. Stresses that sound and light travel through air at different speeds.	Gr. 6 - **	

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
5. The Effects of the Ionosphere on Radio Wave Propagation ** U.S. Off. of Educ., 1951; 29 min., b&w Explains the characteristics of propagated radio waves at various frequencies, ground and sky waves, effect of the ionosphere on sky waves, and the effects of favorable and unfavorable atmospheric conditions.	Gr. 11 - **	
6. Fundamentals of Acoustics ** EBF, 1950; 11 min., black & white Compares sound waves with water waves, provides examples of echoes and explains how they affect acoustics indoors, demonstrates effects of different wall surfaces upon the reflection of sounds, portrays the mechanics of our hearing process, dramatizes the range of the human voice, reveals the effects of eliminating certain vibrational frequencies and identifies ultrasonics.	Gr. 11 - **	
7. Heat--Its Nature and Transfer * EBF, 1958; 11 min., black & white Combines live photography with animated drawings to explain the nature of heat and some of the principle ways in which heat is transferred. Deals with such characteristics of heat as conduction, convection, and radiation; develops the concept of insulation; and illustrates and discusses practical applications of heat in home and industry.	Gr. 9 - Gr. 5 - ** Gr. 11 -	For review No eval. yet

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
8. How to Bend Light ** EBF, 1961; 11 min., color Uses visual devices and demonstrations to show how light can be reflected and bounced off objects, and to explain how mirrors, prisms, and lenses can be used to bend light.	Gr. 6 - **	
9. Learning About Heat * EBF, 1958; 8 min., black & white Identifies and describes the characteristics of heat. Points out that hands get cold because heat, not cold, is transferred. Uses animation to explain expansion and contraction according to the theory of molecular activity as a solid is changed to a liquid and then to a gas. Discusses the three methods of heat transference and ends with a review of the concepts.	Gr. 9 - Gr. 5 - **	Also listed Energy from Matter
10. Learning About Light ** EBF, 1958; 8 min., black & white Depicts the need for light in order to see and illustrates and defines the concepts of luminosity, reflection, translucency, transparency, opacity, and refraction. Shows by means of an animated drawing of a steamship that light cannot bend around the earth. Concludes by reviewing the basic concepts.	Gr. 6 - **	

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
11. Learning About Sound ** EBF, 1958; 8 min., black & white Develops the concept of sound and discusses its generation and transmission. Shows how the vibration of a string produces sound. Uses animation to depict air vibration, illustrates the vibration of a drum head by using iron filings and the concept of vibration of air columns in the example of a willow whistle; portrays sound graphically through the use of an oscilloscope. Demonstrates the transmission of sound through air, water, and metal, and ends with a review of concepts and questions.	Gr. 9 - Gr. 2 - ** Gr. 6 - *	Simple, but good
12. Lenses ** United, 1951; 10 min., black & white Through the use of prisms, shows how diverging and converging lenses defract light. Demonstrates the formation and characteristics of images by placing objects at varying distances from the focus. Includes animated diagrams.	Gr. 11 - **	
13. Light and Color * EBF, 1961; 11 min., color Uses illustrations and experiments to explore the science of color, explaining what color is, how it is related to light, how the eye sees color, and how color can give us information about things.	Gr. 6 - *	

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
14. Light Waves and Their Uses ** EBF, 1937; 11 min., black & white Discusses the principles of reflection and refraction of light, illustrating refraction through lenses, and reflection from plane, concave, and convex mirrors. Explains the human eye as a lens, depicts the use of light waves in making minute measurements, and calls attention to interference, electromagnetic spectrum, and principles and uses of polar screens.	Gr. 11 - **	
15. The Nature of Color ** Coronet, 1957; 11 min., color Duplicates Newton's experiment which explains the nature of the rainbow, demonstrates the principles of color reflection and absorption, shows the mixing of colors by addition and by subtraction, and explains the application of color principles to painting, printing, and photography.	Gr. 11 - **	
16. The Nature of Heat * Coronet, 1953; 11 min. Explains that heat is the energy of the motion of molecules. Experiments are used to demonstrate that heat is transferred by conduction, convection, and radiation. Shows the effectiveness of various types of materials in the transfer of heat.	Gr. 11 - *	

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
17. The Nature of Light * Coronet, 1948; 11 min. Observes, through the eyes of two youngsters, the principles of reflection and refraction; studies light as a form of radiant energy; and explains these principles as applied to the science of optics.	Gr. 6 - * Gr. 11 - **	First half
18. The Nature of Sound ** Coronet, 1947; 11 min. Through everyday examples, explains the nature of sound. Studies the principles of sound's vibrations; its characteristics, and transmission; and pictures sound on an oscilloscope.	Gr. 6 - ** Gr. 11 - *	
19. Radio Waves ** McGraw-Hill, 1961; 27 min., color To increase man's understanding of the behavior of radio waves - man-made and natural, as well as the structure and role of the ionosphere.	Gr. 9 - Gr. 11 - *	A little diff.
20. Refraction ** United, 1951; 8 min., black & white Demonstrates refraction by such analogies as that of wheels moving from a smooth surface onto sand. Explains critical angle and total internal reflection and shows their applications in the submarine periscope and in binoculars.	Gr. 6 - * Gr. 11 - *	Difficult

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
21. Science of Light ** Churchill-Wexler, 1960; 11 min., color Presents various concepts about light and sight. Uses animation, photomicrography and the visualization of experiments difficult to do in the classroom in a discussion about refraction, the speed of light, how we see, where light goes, how light reflects from different surfaces, how it is absorbed and changed to heat, and how light is transmitted through opaque, translucent, and transparent materials.	Gr. 6 - *	
22. Science of Musical Sounds A C D, 1964; 11 min., color Provides an introduction to the basic principles of sound production. Uses three types of musical instruments -- harp, flute, and xylophone -- to illustrate the principles. Defines frequency, vibrations, tuning. pitch, and overtones. Shows how an oscilloscope is used to draw electronic pictures of sound vibrations.	Gr. 9 - Gr. 6 - *	No eval. yet
23. Sounds and How They Travel Academy, 1965; 11 min., color Presents the mechanics involved in the transmission, reflection, and absorption of sound. Shows the transmission of sound through various materials such as water, metal and wood. Describes the reflection of sound waves and the formation of echoes. Explains the absorption of sound waves and the control of echoes. Shows how echoes can be useful.	Gr. 9 - Gr. 6 -	No eval. yet No eval. yet

* Good
** Excellent

Common forms of wave energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
24. Sound Waves and Their Sources * EBF, 1950; 11 min., black & white Shows how sounds in our environment originate in an object that vibrates, and explains the meaning of loudness, pitch, and quality.	Gr. 11 - **	
25. Speed of Light * EBF, 1955; 20 min., black & white Reviews the numerous historic attempts to measure the speed of light and describes more recent experiments that led to the determination of C; dramatizes Galileo's experiments, Roemer's study of Jupiter's satellites and his determination of C. Fizeau's toothed wheel experiment, and finally, the mirror methods used by Foucault and Michelson. Applies the concept of C to modern physics and develops it as a universal stick.	Gr. 9 - Gr. 11 - **	Also listed in Introduction
26. Vibrations ** EBF, 1961; 13 min., color Explains the causes and effects of vibrations and demonstrates the basic concepts necessary for the understanding of vibrations. Presents examples which illustrate that sounds are the results of vibrations, that rapid vibrations can be heard, and that objects which vibrate slowly cannot be heard.	Gr. 6 - **	

* Good
** Excellent

Nuclear structure and sources of energy

Name and Description of Film	Other Grade Placements	Remarks
1. The Atom and Industry * EBF, 1952; 11 min., black & white Illustrates the use of radioisotopes in providing new techniques of measurement and quality control in the oil, automobile, and paper industries.	Gr. 11 -	No eval. yet
2. Atomic Energy * EBF, 1947; 11 min., black & white Explains by animated drawings the concepts basic to an understanding of atomic energy; identifies parts and structure of atoms; explains the three known forms of atomic energy release--natural radioactivity, nuclear synthesis, and nuclear fission; and illustrates relationship between atomic energy from the sun and chemical energy stored and released in photosynthesis and combustion.	Gr. 11 - **	
3. Atomic Energy--Inside the Atom ** EBF, 1961; 13 min., color Visualizes in animation the structure of the atom; shows in demonstrations involving the cloud chamber and the Geiger counter, the power of the atom, and observes its uses in a hospital, an atomic power plant, and an atomic submarine.	Gr. 6 - *	
4. Atomic Physics. Part 1: The Electron * United, 1950; 25 min., black & white Presents historical discoveries leading to the electron, qualities of the electron, measurement of charge of the electron, and industrial uses of the electron.		

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
5. Atomic Physics. Part 2: Rays from Atoms * United, 1950; 25 min., black & white Explains Thomson's work on positive rays, Ashton's mass spectrograph, production and use of X-rays, radioactivity, and apparatus for detecting and recording sub-atomic emissions.		
6. Carbon Fourteen * EBF, 1953; 12 min., black & white Explains the use of radiocarbon as a means of determining the age of historic and prehistoric objects; shows how carbon fourteen is being used in studying the process of photosynthesis; and describes experiments at the Argonne National Laboratory near Chicago which are being conducted for the purpose of studying the effect of radiation upon plants.	Gr. 10 - ** Gr. 11 - **	
7. Cosmic Rays ** McGraw-Hill, 1961; 27 min., color To establish a broader understanding of cosmic rays and of present day research on their nature and origin. Cosmic ray research has led to knowledge of basic structures of the nucleus.	Gr. 11 - **	
8. Electrons at Work ** EBF, 1961; 14 min. Presents examples of electrons at work, showing how they supply energy to turn a paddle wheel, to create a picture on a television screen, and to operate an electronic computer. Uses simple experiments and demonstrations to illustrate the characteristics of electrons and to show how they can be controlled for useful purposes.	Gr. 5 - **	

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
9. Fundamentals of Radioactivity * U.S. Off. of Educa., 1952; 59 min., b&w A survey film, first of a series, explaining basic concepts in the field of nuclear physics necessary to an understanding of radioisotopes. Describes in detail the origins of nuclear radiation and the chain reaction of uranium as a means of producing radioisotopes. Primarily for technical use.	Gr. 9 - Gr. 11 - **	Advanced
10. Hoover Dam ** U.S. Off. of Educa., 1950; 33 min., b&w Reviews the building of Hoover Dam and explains its values in furnishing irrigation water and electric power to the people in the southwestern United States.	Gr. 5 - **	
11. The Medical Effects of the Atomic Bomb. Part 1: Physics, Physical Destruction, Casualty Effects ** U.S. Off. of Educa., 1951; 32 min., color Gives an explanation of nuclear physics, fission, and general reaction, thermal energy and mechanical force, nuclear radiation and ionizing effects; and portrays the physical destruction and casualty effects of atomic bombing.		

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
12. Neutrons and the Heart of Matter ** Educa. Test. Serv., 1960; 20 min., color Dr. Donald J. Hughes, senior physicist at Brookhaven National Laboratory, describes the important research in atomic and nuclear physics which is underway. Shows the nuclear reacter which is a source of relatively slow-moving subatomic particles, the "fast chopper" which is a rapidly rotating shutter which breaks up a beam into short bursts of neutrons which can be measured with great precision, and the bubble chamber which gives actual pictures of collisions between the subatomic bullets and atomic nuclei in the target.		
13. Nuclear Radiation: Fallout ** Cenco Inst. Corp., 1961; 14 min., color Defines radioactive fallout as being of two types: immediate and delayed. Explains sources of these two types of fallout. Explains the concept of half-life and the resulting progressive decay at different rates of different radioactive sources. Suggests ways people can use to protect themselves from fallout.	Gr. 11 - **	
14. Nuclear Radiation: In Earth Studies ** Cenco Inst. Corp., 1961; 15 min., color Shows how radiation detection devices can be used in aerial survey work for locating promising radioactive minerals. Also shows how aerial surveys must be followed up by ground survey parties in order to locate more specifically the valuable, radioactive minerals.	Gr. 9 - Gr. 11 - **	Advanced

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
15. Our Friend the Atom ** Walt Disney, 1957; 50 min., color Traces the history of man's efforts to solve the mysteries of the atom from the first guesses of Democritus to the latest successes of modern scientists; discusses the significance of the Einstein equation, control of nuclear fission, implications of atomic developments for transportation, medicine, agriculture, and electric power; and the responsibilities imposed on society by the new energy source. Includes animated sequences.	Gr. 9 - Gr. 11 - **	Also listed in Introduction
16. The Practice of Radiological Safety * U.S. Off. of Educa., 1952; 33 min., b&w Shows how shipments of radioactive materials are handled, doses for therapy prepared, and synthetic compounds manufactured; pictures the protective clothing and the metering equipment worn by personnel handling radioactive materials; emphasizes safety precautions.	Gr. 11 - **	
17. The Strange Case of the Cosmic Rays ** N.W. Bell Tele., 1960; 60 min., color To tell the story of how scientists around the world track cosmic rays and establish their mysterious character and behavior, Frank Capra, producer, uses actors, animation and cartoon characters, science motion pictures and puppets. Stars in this picture are Dr. Frank Baxter and Richard Carlson. A Bell System "Science" series film.	Gr. 5 - ** Gr. 11 - **	

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
18. The Sun's Energy ** Academy Films, 1960; 16½ min., color This film explains why the sun's energy is the basic of all life on earth and the source of all types of industrial energy except atomic energy. Green leaves of plants use the sun's energy to manufacture food, which is stored in fruits, seeds, stems and roots. Human beings get much of their energy by eating the seeds, fruits and roots of many different plants. So directly or indirectly, plants sustain all animal life and green plants depend on sunlight.	Gr. 5 - ** Gr. 8 - **	
19. Unlocking the Atom ** United, 1951; 20 min., black & white Reviews the work of atomic scientists from the early 19th century to the present. Through animated diagrams demonstrates the behavior of radioactive elements; presents Einstein's mass-energy formula; explains the cyclotron and its uses. Discusses the principles governing chain reaction and the nature of key A-bomb materials, the uses of atomic energy in warfare, and the potential applications of atomic power in medicine and industry.	Gr. 11 - **	
20. Waves and Energy ** EBF, 1961; 11 min. Explains that there are many kinds of waves, including water, sound, light, and radio waves. Uses illustrations and experiments to show how waves carry energy from one place to another. Describes the relationship between frequence and wave length; and explains how radio waves carry information.	Gr. 5 - **	

* Good
** Excellent

Nuclear structure and sources of energy (continued)

Name and Description of Film	Other Grade Placements	Remarks
21. We Use Power * Churchill-Wexler, 1957; 11 min. Joan and Jimmie observe a series of experiments showing the use of the power in wind, water, steam electricity, and internal combustion engines. Small, simplified models are used.	Gr. 5 - **	

* Good
** Excellent

Aerospace

Name and Description of Film	Other Grade Placements	Remarks
1. ABC of Jet Propulsion ** Gen. Motors, 1959; 17 min., color An animated film which explains how a jet engine works and how it differs from other internal combustion engines.	Gr. 6 - ** Gr. 12- *	
2. Air Age * M G H, 1959; 26 min., black & white Records man's conquest of the air from the Wright Brothers' first flight at Kitty Hawk to the development of man-carrying rockets.	Gr. 9 -	Review of History to 1955
3. Air in Action Coronet, 1947; 11 min. Explains the principles and applications of air in action. Illustrates these principles with ping-pong ball experiments, wind tunnel testing, airplanes in flight, and animated drawings of other experiments.	Gr. 9 - Gr. 11 -	No eval. yet No eval. yet
4. The Big Bounce ** N.W. Bell Tele., 1961; 14 min., color This documentary shows the actual satellite communications experiments sponsored by the National Aeronautics and Space Administration. It reveals how this may lead to world-wide space communications systems of the future. The experiments of Bell Telephone Laboratories in New Jersey and the Jet Propulsion Laboratory in California, are shown.	Gr. 6 - * Gr. 11 - *	

* Good
** Excellent

Aerospace (continued)

Name and Description of Film | Other Grade Placements | Remarks

5. Earth Satellites--Explorers of Outer Space ** Gr. 6 - **

EBF, 1959; 17 min.

Scenes at the Army and Navy launching site show satellites being built, prepared for launching, and taking off. Uses animated drawings to explain why satellites stay in orbit, how orbits may vary, and how information is received from satellites. Includes a sequence describing things to come in the space age.

6. Exploring by Satellite ** Gr. 8 - **

C E F, 1960; 28 min., color

Uses live action and animation to explain the earth satellite program, to describe the physical laws involved. Discusses the scientific methods used; tells about the data obtained in the Vanguard experiment during the International Geophysical Year.

7. Exploring the Edge of Space ** Gr. 12 - **

Educ. Test. Serv., 1959; 19 min., color

Shows how man's plans to conquer space have been materially advanced by the plastic balloon. Introduces Otto C. Winzen, developer and experimenter of the plastic balloon in scientific research. Shows the huge envelope of polyethylene film with a parachute and scientific equipment attached, the introduction of the proper amount of helium, and the climb of the balloon. Includes scenes of the historic Manhigh Flight in 1957 in which a man was sent into space to 100,000 feet.

* Good
** Excellent

Aerospace (continued)

Name and Description of Film	Other Grade Placements	Remarks
8. Helicopters * EBF, 1954; 11 min., black & white Explains the principles of helicopter flight. Surveys the uses and potentialities of the helicopter.		
9. Jet Propulsion ** EBF, 1952; 11 min., black & white Illustrates the physical principles on which jet propulsion is based and describes the operation and uses of several types of jet engines.	Gr. 11 - ** Gr. 12 - *	
10. Man and the Moon * Walt Disney, 1957; 20 min., color This film presents a realistic and believable trip to the moon in a rocket ship - not in some far-off fantastic never-never land, but in the near, foreseeable future. It will provide food for sober thought for the mature viewer and stimulation and motivation for young people considering future vocations.	Gr. 6 - **	
11. Man in Space ** Walt Disney, 1957; 35 min., color Depicts the development of rockets from the ancient Chinese weapons to modern missiles, and shows how man may conquer outer space and establish a manned satellite 1,075 miles above the earth. Includes animated sequences.	Gr. 6 - ** Gr. 11 -	 No eval. yet

* Good
** Excellent

Aerospace (continued)

Name and Description of Film	Other Grade Placements	Remarks
12. Mars and Beyond ** Walt Disney, 1958; 30 min., color Discusses the temperature and atmosphere on the planets, and the conditions necessary to sustain life. Explains man's earliest concepts of the planets, particularly Mars. Pictures the possible surface of Mars and the ways in which plant and animal life may have adapted to conditions there. Describes an imaginary flight to Mars in an atom-powered space ship.	Gr. 5 - ** Gr. 6 - ** Gr. 8 - **	
13. Nuclear Radiation in Outer Space ** C E F, 1961; 18 min., color Stresses that radiation in outer space is one of the largest natural hazards that exist in space. Discusses the types of radiation as either electromagnetic or corpuscular form. Uses animation to show how radiation varies with the intensity of the sun and the height of a body above the earth. Shows preparation of living cells and exposure of these to space in balloon and rocket flights. Concludes with a summary of the major points of the film.		
14. Problems of Flight ** EBF, 1941; 11 min., black & white Explains and illustrates major principles of flight maneuvers. Demonstrates manipulation of the plane's controls while taking off, climbing, banking, stalling, spinning, diving, gliding, and landing. Contrasts different techniques of various maneuvers with special emphasis on gliding and landing. Through animated drawings superimposed over natural photography explains the forces acting upon the plane during flight.	Gr. 11 - ** Gr. 12 - **	

* Good
** Excellent

Aerospace (continued)

Name and Description of Film	Other Grade Placements	Remarks
15. Research by Rockets ** McGraw-Hill, 1961; 27 min., color Research and power of rockets is stressed and their functional application as devices to permit man to extend his knowledge of his planet and the cosmos is thematic.		
16. Rockets: How They Work ** EBF, 1958; 14 min. Uses animated models and drawings to show how rockets achieve motion, and compares rocket power with other types of motive power. Scenes at a rocket launching site shows the count-down procedure and the take-off of a giant multi-stage rocket. Demonstrates the functioning of a rocket guidance system.	Gr. 6 - **	A little diff.
17. Rockets: Principles and Safety ** Film Assoc. of Calif., 1959; 11 min. Describes the physical principles upon which rockets work; explains why rocket motors can work in the absence of air; and stresses that rockets are dangerous and should not be built or fired by amateurs.	Gr. 6 - **	A little diff.
18. Satellites: Stepping Stones to Space ** Film Assoc. of Calif., 1959; 18 min. Through animation, models and live action photography the film shows the construction and instruments of Explorer I and explains how it was put in orbit. Demonstrates why satellites stay up, what determines their lifetimes, and how they record information.	Gr. 6 - **	

* Good
** Excellent

Aerospace (continued)

Name and Description of Film	Other Grade Placements	Remarks
19. Science in Space ** McGraw-Hill, 1961; 27 min., color Explanation of development of the artificial satellites and space probes, and to relate them to modern geophysical research.		
20. Screen News Digest, Volume 4, Issue 8 (Flight of Friendship 7) ** Hearst Metrotone News, 1962; 20 min., b&w Covers the flight of the Friendship 7 which includes a hero's welcome....happy landings....in orbit....in the Friendship 7....a moment of prayer...three....two....one.	Gr. 6 - **	
21. Theory of Flight ** EBF, 1941; 11 min., black & white Explains basic principles of airplane flight by illustrating the application of physical laws to forces acting on airfoils. Through wind tunnel demonstrations shows the relations of air velocity to lift and drag on flat and cambered airfoils. Demonstrates the functions of the rudder, elevator, and ailerons. Illustrates actions of the plane when pitching, rolling, and yawing.		
22. A Trip to the Moon ** EBF, 1957; 16 min. Shows an imaginary rocket as it takes off to the moon and hovers above it, explaining many facts necessary for an understanding of navigation to the moon. Combines animation and model photography to study the moon's surface, and shows in detail the craters and seas, ridges and mountains that can be seen from the earth.	Gr. 5 - ** Gr. 6 - ** Gr. 8 - ** Gr. 11 -	No eval. yet

* Good
** Excellent

SCIENCE MOTION PICTURE FILMS - Grade Nine
(Addendum)

Additions to
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Aerospace

Name and Description of Film	Other Grade Placements	Remarks
Air in Motion ** MGH, 1956; 18 min., b/w Uses simple experiments to illustrate how an airplane flies and demonstrates the fact that moving air has less pressure than still air.	Gr. 4 - **	
Apollo: Journey to the Moon ** MGH, 1964; 26 min., color The problems of making a successful round trip to the moon and a manned landing on its surface are discussed by Astronaut's Shepard, Glenn, Young, Elliott M., McDivitt, and Lovell. Topics covered are: The rocket vehicle, Countdown-to- blast off-to orbit, Achieving a lunar trajectory and docking maneuvers, Lunar landing maneuvers, Lunar explorations, The return to Earth.		
First Man in Space ** EBF, 1962; 16 min., b/w This film re-creates, with scale models, animation, and live photography, the first American orbital space flight. It also shows how space survival problems were scientifically studied and solved in ground laboratories, and how the solutions were applied by engineers to the first space capsule.	Gr. 6 - **	Needs preparation

* Good
** Excellent
5/23/67

SCIENCE MOTION PICTURE FILMS - Grade Nine
(Addendum)

Additions to
Page 50

Aerospace (continued)

Name and Description of Film	Other Grade Placements	Remarks
Dr. Goddard To Project Gemini ** Focus Story: The Space Age - A Special Report MNN, 1965; b/w Presents the story of the space age - recalls its beginning in 1919 when Robert Hutchings Goddard wrote a scientific paper entitled, "A Method of Reaching Extreme Altitudes." Follows the experiments of rocket propulsion. Shows how European scientists closely followed American progress and all models were of the same basic design. Describes the progress of rocketry since World War II - Russia's first satellite - 1957, Russian orbit of the dog - 1957 America sends aloft a chimpanzee - 1961, Russian orbit of a human - 1961, John Glenn orbits in Friendship 7 - 1962, Russian Cosmonaut leaves spacecraft for 10 minutes - 1965, America's first Gemini Mission sends Grissom and Young on a three orbit flight in which man, for the first time, maneuvers his spacecraft - 1965.	Gr. 6 - **	
Project Gemini - The Next Step in Space * MNN, 1963; b/w Presents an attempt for rockets to meet in space - target date, late 1964 or early 1965. Relates that an Atlas-Agena launch vehicle will be fired from Cape Kennedy; Gemini capsule to contain two astronauts who locate and attach to Agena, stay aloft at least a week and pioneer a new way of returning to earth.		

* Good
** Excellent
5/23/67

For discussion purposes only

SCIENCE FILMSTRIPS

(35 mm.)

for
Grade Nine

Correlated to the Major Topics and/or Units
as found in the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department

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The annotations for filmstrips found on the following pages were obtained from sources such as the Wilson's Filmstrip Guide, producers' catalogs, and the Library of Congress cards.

III. Energy--Sources and conservation of energy

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. World's Matter Supply ** McGraw-Hill Book Co., 37 fr., color (General Physical Sciences, 6 f.s.) Set-$45.00, Each-$8.50 This filmstrip surveys the world's matter resources; indicates their usefulness; and stresses the need for using them wisely. The Law of Conservation of Matter and Energy is stressed, and emphasis is placed on the fact that the resources are found in all four spheres of the earth. These resources are discussed in the terms, "renewable" and "non-renewable".		

* Good
** Excellent

III. Energy--Energy, force and motion

B. Machines

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Simple Machines Make Work Easier ** McGraw-Hill Book Co., 1955, 40 fr., color (General Science Series, Set 2, 7 f.s.) Set-$42.50, Each-$6.75 Discusses the basic principles of simple machines; explains the concept of mechanical advantage; demonstrates the application of simple machines in everyday life; and illustrates the arithmetic solution of simple problems involving simple machines.		

* Good
** Excellent

III. Energy

A. Magnetic energy

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Magnetic Fields ** Jam Handy Organization, 1960; 40 fr., color (Magnets Series, 6 f.s.) $5.75 each Students see a short history of magnets leading to their use in compasses. They observe how poles repel and attract each other. Through experimentation, they learn about lines of force and the earth's magnetic field.	Gr. 2 - ** Gr. 4 - *	
2. Magnets Can Attract Through Objects * Jam Handy Organization, 1960; 32 fr., color (Magnets Series, 6 f.s.) $5.75 Two children find that a magnet will attract iron and steel through glass, wood and other materials. They see how a magnet has a variety of uses in the home.	Gr. 2 - * Gr. 4 - *	
3. What Is A Magnet? * Benefic Press, 1961; 40 fr., color (6 f.s. in series) $ Presents basic facts about magnets.	Gr. 4 - **	
4. What Is Magnetism? ** Jam Handy Organization, 1960; 40 fr., color (Magnets Series, 6 f.s.) $5.75 each The class shows why magnets act as they do. Students learn how the molecular and electron theories explain magnetism. They see the proper way to keep magnets.		

* Good
** Excellent

III. Energy--Electrical energy

A. Static electricity

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. What is Static Electricity? * Jam Handy Organization, 1960; 41 fr., color (Understanding Electricity, 7 f.s.) $5.75 each How the electron theory explains static electricity, experiments and everyday experiences which portray this phenomenon.	Gr. 5 - **	

* Good
** Excellent

III. Energy--Electrical energy

B. Current electricity

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Electromagnets and How They Work * Jam Handy Organization, 1960; 38 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each An electromagnet solves a problem, how electromagnets are similar to and different from other magnets, how their polarity can be determined, how their strength can be increased, use of electromagnets.	Gr. 5 - **	
2. Electrons Produce Our Light ** McGraw-Hill Book Co., 1959; 41 fr., color (General Science Series, Set 4, 6 f.s.) Set-$36.50, Each-$6.75 Presents the historical background of electric lighting, describing the principle of arc lamps, the principles of incandescent lighting, and the principles of fluorescent and newer means of electric illumination.		
3. How AC and DC Motors Work * McGraw-Hill Book Co., 1958; 39 fr., color (General Science Series, Set 3, 6 f.s.) Set-$36.50, Each-$6.75 Develops the principle of the AC and DC motors; demonstrates various types of DC motors; studies the magnetic fields of AC and DC motors; and presents simple experiments with AC motors.		

* Good
** Excellent

III. Energy--Electrical energy - B. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
4. How is Electricity Used in the Home? * Jam Handy Organization, 1960; 47 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each How common appliances such as the toaster work, how an incandescent light works, how a motor works, how a switch is used to control the flow of electricity.	Gr. 5 - **	
5. How Most Electricity Is Produced * Jam Handy Organization, 1960; 35 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each The principle of a generator is developed through demonstrations with a galvanometer and a magneto, how other forms of energy are changed to electrical energy through the use of the turbine.	Gr. 5 - **	
6. Producing Small Amounts of Electricity * Jam Handy Organization, 1960; 34 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each How dry cells and wet cells produce electricity through chemical action, simple experiments related to chemical action with common materials, how other forms of energy are changed to electrical energy.	Gr. 5 - **	

* Good
** Excellent

III. Energy--Electrical energy - B. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
7. Using Electricity Safely * Jam Handy Organization, 1960; 36 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each Why electricity can be dangerous, how short circuits and overloaded circuits cause fires, precautions to be taken in situations involving the safe use of electricity.	Gr. 5 - **	
8. What Is Current Electricity? * Jam Handy Organization, 1960; 35 fr., color (Understanding Electricity Series, 7 f.s.) $5.75 each How the electron theory explains current electricity and the advantages of this form of energy; how it can be changed to other forms of energy.	Gr. 5 - **	
9. What Is Electricity? * Benefic Press, 1961; 40 fr., color (6 f.s. in series) $ Presents basic facts about electricity.		

* Good
** Excellent

III. Energy--Common forms of wave energy

A. Light and ultraviolet radiation

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Science of Color Photography * McGraw-Hill Book Co., 1958; 40 fr., color (General Science Series, Set 3, 6 f.s.) Set-$36.50, Each-$6.75 Discusses the history of color photography and shows the important place that color photography has in modern life. Compares color with black and white photography, shows steps in the processing of color film, and demonstrates the color separation process.		
2. The Story of Lenses * McGraw-Hill Book Co., 1958; 43 fr., color (General Science Series, Set 3, 6 f.s.) Set-$36.50, Each-$6.75 Demonstrates refraction; shows the evolution of lenses from prisms and the differences among lenses; illustrates methods for determining focal length and the application of different types of lenses.		
3. What Is Light? * Benefic Press, 1961; 40 fr., color (6 f.s. in series) $ Presents basic facts about light.	Gr. 6 - *	Vocabulary difficult

* Good
** Excellent

III. Energy--Atomic structure and nuclear energy

A. Nature of the atom

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. The Atom ** McGraw-Hill Book Co., 37 fr., color (General Physical Sciences Series, 6 f.s.) Set-$45.00, Each-$8.50 This filmstrip deals with the nature and composition of the atom, the basic unit of matter. The filmstrip shows how changes of the nucleus of the atom cause the release of energy. Attention is directed to the relative sizes of the different atoms, and to the meaning of the term, "isotope" and the ways in which atoms combine to form molecules.		
2. Putting Atomic Energy to Work ** McGraw-Hill Book Co., 1954, 46 fr., color (Modern Physics Series, Set 1, 8 f.s.) Set-$37.00, Each-$7.00 The filmstrip opens with a development of the concept of heat production in atomic reactors, followed by the common methods of cooling by air and water. The changing of waste heat into power for propelling a submarine is developed. The pictures show that an atomic power plant is similar in most respects to a steam power plant with the exception of the pile and heat exchanger which replaces the fuel and the boilers. Students observe the use of radioactive isotopes in fighting disease, in agriculture, in making steel, in measuring devices, for locating breaks in pipes, etc.		

* Good
** Excellent

III. Energy--Atomic structure and nuclear energy - A. (continued)

Name and Description of Filmstrip | Other Grade Placements | Remarks

3. Scientific Measurement--Molecules to Stars **

McGraw-Hill Book Co., 1959, 40 fr., color
(General Science Series, Set 4, 6 f.s.)
Set-$36.50, Each-$6.75

Deals with an experiment on molecular dimensions as first performed by Dr. Langmuir. Demonstrates the basic importance of measurement in scientific work, and shows methods for measuring extremely short distances, for approximating molecular dimensions, and for measuring great distances.

4. Using Atomic Energy **

McGraw-Hill Book Co., 1957; 39 fr., color
(General Science Series, Set 2, 7 f.s.)
Set-$42.50, Each-$6.75

Discusses the basic principles of power reactors; shows how enriched uranium power reactors operate and how breeder reactors work; describes methods used to transfer heat from an atomic reactor to a steam turbine; and demonstrates the different types of atomic power reactors that are in use or under construction.

5. What's in the Atom? **

McGraw-Hill Book Co., 1958, 42 fr., color
(General Science Series, Set 3, 6 f.s.)
Set-$36.50, Each-$6.75

Discusses the makeup of the atom and of atomic particles. Compares atomic particles with the proton, neutron, and electron, and presents basic ideas of antimatter.

* Good
** Excellent

Aerospace--A summary unit

A. Aircraft in flight

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. How Airplanes Fly ** McGraw-Hill Book Co., 1954, 46 fr., color (Modern Physics Series, Set 1, 8 f.s.) Set-$37.00, Each-$7.00 The filmstrip opens with simple experiments that illustrate the reduction of pressure of the air flowing over curved surfaces. Two closely suspended ping-pong balls move together instead of apart when air blows at them. This principle is applied to a curved sheet of paper which is made to fly. A section of a real airplane wing mounted on a balance is shown. In a stream of air the wing flies and lifts the balance. Three types of airplanes are shown: the glider, the propeller plane, and the jet plane.		
2. How Do Helicopters Fly? ** Jam Handy Organization, 1961; 33 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the rotary wing provides both lift and thrust for a helicopter. How the pilot controls the helicopter. Various types of helicopters and the many important jobs they can do.	Gr. 6 - **	
3. How Do Jets Fly? * Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings. How a jet engine works. Examples and experiments demonstrate the principle of action and reaction. The sound barrier. Advantages of jets over propeller-driven planes.	Gr. 6 - **	

*	Good
**	Excellent

Aerospace--A summary unit - A. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
4. How Is An Airplane Controlled? ** Jam Handy Organization, 1960; 29 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings. How the elevators, rudder, ailerons and flaps are used in controlling a plane. How the pilot operates these control surfaces to maneuver his plane.	Gr. 6 - **	
5. Jets and Atomic Power * McGraw-Hill Book Co.; 1952, 49 fr., color (Modern Physics Series, Set 1, 8 f.s.) Set-$37.00, Each-$7.00 The filmstrip opens with a cartoon of a boy posing the problems of jets. The development of jets from their origin in Hero's engine through Newton's third law of motion of action and reaction. The principles of reaction is explained in Hero's engine, and then applied to the flight of a toy balloon across a room as the result of the reaction to the escaping jet of air. From the jet of carbon dioxide, the principle of reaction is carried over to the hot gas exhaust of a real jet engine		
6. Safety In Flight * Jam Handy Organization, 1960; 37 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the study of weather and the use of scientific instruments such as radar and the instrument landing systems contribute to the safety of air travel.	Gr. 6 - **	

* Good
** Excellent

Aerospace--A summary unit - A. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
7. What Makes An Airplane Fly? ** Jam Handy Organization, 1960; 42 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Drawings and paintings. How the propeller and the wing are designed to enable an airplane to fly. The four forces at work during the flight. Experiments with air pressure to show its role in flight. Examples of the ways in which airplanes serve man.	Gr. 6 - **	

* Good
** Excellent

Aerospace--A summary unit

B. Introduction to space travel

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Conditions in Space ** Jam Handy Organization, 1962; 41 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each Atmospheric pressure, sound, light and temperatures are discussed in terms of outer space. Cosmic rays, meteoroids, atomic fragments and magnetic fields in space are also examined.	Gr. 6 - **	
2. Exploring the Space Around Earth * Films for Education & McGraw-Hill Book Co., 1958, 59 fr., color, (The Story of the Universe Series, Set I, The Earth and Its Moon, 6 f.s.) Set-$42.00, Each-$7.50 This filmstrip explains the use of rockets to explore space, clarifies their nature and operation, and discusses how and why they go into orbit or escape from it.	Gr. 8 - **	
3. Rocket Power For Space Travel * Jam Handy Organization, 1960; 40 fr., color (Airplanes, Jets and Rockets Series, 6 f.s.) $5.75 each Paintings and drawings. How a rocket works in airless space. Multistage rockets. Rocket planes. Why satellites and space stations orbit. Problems of space travel of the future.	Gr. 6 - **	

* Good
** Excellent

Aerospace--A summary unit - B. (continued)

Name and Description of Filmstrip	Other Grade Placements	Remarks
4. Space Rockets ** Jam Handy Organization, 1962; 43 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The basic principles of rocket propulsion, the differences between solid and liquid fuel rocket engines, and the solution to man's problem of overcoming the earth's gravity are presented in detail.	Gr. 6 - **	
5. Space Stations ** Jam Handy Organization, 1962; 41 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The means and the principles involved in putting huge space stations into orbit are presented--how the station could be built in space, how pseudo "gravity" may be provided by rotating the wheel-like station and the advantages of such a station.	Gr. 6 - **	
6. What Is a Rocket? * Benefic Press, 1961; 34 fr., color (6 f.s. in series) $ Presents basic facts about rockets.	Gr. 6 - **	

* Good
** Excellent

Aerospace--A summary unit -

C. Navigation and guidance in space travel

Name and Description of Filmstrip	Other Grade Placements	Remarks
1. Exploring the Moon ** Jam Handy Organization, 1962; 39 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each This filmstrip shows how a moonship could be built and launched from the orbit of a manned space station. The moonship is described in detail. A possible route to the moon is investigated. Some of the features of the moon are illustrated.	Gr. 6 - **	
2. Information From the Satellites ** Films for Education & McGraw-Hill Book Co., 1958, 63 fr., color, (The Story of the Universe Series, Set I, The Earth and Its Moon, 6 f.s.) Set-$42.00, Each-$7.50 This filmstrip deals with some of the uses of satellites and the possible future uses of space stations. It considers the transparency of the atmosphere and examines the nature of light and its spectrum. It touches on the possibility of space travel.	Gr. 8 - **	
3. Space Satellites ** Jam Handy Organization, 1962; 40 fr., color (Space and Space Travel Series, 6 f.s.) $5.75 each The basic principles governing the movement of satellites in space are portrayed, as well as the means by which satellites are put into orbit. Elliptical orbits, changing orbits, orbital decay, uses of satellites and other concepts are illustrated.	Gr. 6 - **	

* Good
** Excellent

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EQUIP. & SUPPLIES

7

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

INSTRUCTIONS FOR ORDERING AND REPAIR OF SCIENCE EQUIPMENT AND SUPPLIES

Inventory Maintenance

During recent years each of our schools has been bringing their science facilities, equipment and supplies up to a basic minimum for instruction. It now has become necessary that a running inventory of all materials be kept and be completely checked for accuracy each year. It is realized that this requires hard work, but at the same time it is necessary if we are to keep track, prevent duplication and over-ordering of equipment and supplies which are on hand in the classrooms in the many storage facilities. If you do not now have an inventory of your room, we are asking that in the very near future a complete inventory of all equipment and supplies in your science room be made and checked at least once each year. If you desire, the minimum equipment list (copy of which is available in the Science Department Office) may be used as a basis for developing and keeping this inventory.

Procedures for Ordering

A number of difficulties arise each year during the requisitioning, bidding and purchasing of materials for your science classes. We should like to make the following suggestions regarding requisitions for science materials:

1. Confer with your principal as to the amount of money which you may spend on the purchase of science equipment and supplies.

2. All equipment and materials with complete specifications must be requisitioned on Form 1000. (Please check the typed requisitions for any possible errors).

   a. If it is imperative that certain items be bought from a specific company, group those items on a separate requisition. Give a catalog number and all specifications for each item. (i.e. Grass frogs, preserved, 1-3/4" to 2-1/2" body length).

   b. On all other requisitioned items, please give your preferred company's catalog number. Be sure to include all specifications. (i.e. Microscope slide cover, glass, 22 mm. square, #1 thickness). It is permissible in your requisition for these items to specify, "similar to Cenco No. 19474" or "quality equal or better than Walker No. 4-686". When our purchasing department submits your requisitioned items with all specifications for bids, some money can be saved and you will still get the quality of materials which you desire.

   c. It is suggested that you list all live specimens and cultures on a separate requisition. Future dates for delivery should be indicated, if possible. If date of delivery cannot be determined when the requisition is made, mark requisition, "To be delivered on demand by the instructor".

INSTRUCTIONS FOR ORDERING AND REPAIR OF SCIENCE EQUIPMENT AND SUPPLIES (cont.)

3. Use the most recent catalog and price list for all requisitioned items. Prices are increasing all the time. Be sure to allow for some possible price increases when requisitioning. (May we suggest that you put the least needed items at the bottom of the requisition and indicate which ones may be dropped from your order if your science allotment does not cover all items, due to price increases?) The prices which we receive on bids are the only guaranteed prices--catalog prices are not guaranteed prices! Most scientific supply companies tell us that they cannot furnish a new catalog to each teacher. When the Science Office receives a new catalog for your school, we send it to your librarian.

4. The list of scientific equipment and supply companies and their respective representatives is for your use. Please keep it for your future reference. If you receive materials from any company which do not meet your specifications as included on your requisition, it is your responsibility as the science instructor to immediately contact the company or its representative and see that the Minneapolis Public Schools secure value received from the equipment companies.

If we can be of any assistance in locating science equipment or supplies which you need in instruction, do not hesitate to call upon us for assistance.

Procedures if New Equipment or Supplies Arrive Damaged:

When newly ordered equipment or supplies arrive in a damaged condition,

(1) the public carrier (usually the Post Office or the Railway Express) should be informed immediately of such damage. In most cases they will send one of their men to examine the carton and damaged equipment. It will be necessary for you to work with your requisition clerk to see that this is carried out. Following this examination by the public carrier you should,

(2) inform the scientific supply company from whom you have purchased this material that it was damaged in transit and you desire replacements. This cannot be done by the clerks in the Central Office as they do not understand the conditions that exist in your school building. Please have your building requisition clerk do this letter writing for you.

It is necessary that you, as the classroom science instructor, see that our Board of Education secures value received and equipment which is ordered and paid for. May we ask your assistance in carrying out both of these steps as indicated above?

Procedures for Repair of Equipment

As equipment is used in the teaching of science, it eventually wears out or may become unavoidably damaged. When a piece of equipment is no longer usable for science instruction, it should be repaired and returned to service or be removed from your inventory and the Board of Education inventory kept in the Finance Department. If you desire any assistance regarding decisions to repair equipment or remove it from inventory, do not hesitate to call upon the Science Department Office for suggestions.

INSTRUCTIONS FOR ORDERING AND REPAIR OF SCIENCE EQUIPMENT AND SUPPLIES (cont.)

If you believe a specific piece of equipment can be repaired, you should carry out the following steps in cooperation with your requisition clerk:

1. Write a letter to the manufacturer or supplier of the equipment requesting directions for shipment of the equipment to them for possible repair. Be sure to instruct them in the letter that upon receipt of the equipment, they are to examine the equipment and then send you a firm bid for the price of the repairs. Warn them that they are not to repair the equipment until they have received a "purchase order" for the work. When you receive the letter of firm bid and shipping instructions from the manufacturer, ship the equipment as directed and proceed with the next step.

2. When you receive the firm bid and you feel that the estimated cost of repair is within reason, you should have a request for repair filled out on the regular requisition blank, form 1000, and fasten the firm bid letter to it. Forward this requisition to the Board of Education Business Office and they will follow through on sending the purchase order to the manufacturer. If you feel that the cost of repair is too great, request the manufacturer or supplier to return the equipment to you. Before you dispose of the equipment contact the Science Department Office for advice.

3. When the equipment has been repaired and returned to you in satisfactory condition, sign the blue copy of the purchase order which your requisition clerk has in her files. Have this blue copy forwarded to the Board of Education Business Office for payment.

Many pieces of science equipment can be repaired locally such as compound microscopes and aquariums. If the Science Department Office can be of assistance to you in locating sources of repair, do not hesitate to call them.

Audio visual equipment needing repairs should be referred to the building audio-visual coordinator.

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Revised 3-16-65

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

SUPPLIERS OF SCIENCE EQUIPMENT AND MATERIALS AND THEIR REPRESENTATIVES

Aloe, Division of Brunswick Corp.
3501 Raleigh Avenue
Minneapolis, Minnesota 55416
927-7351
Rep. A.C. Rink

American Optical Company
2616 Nicollet Avenue
Minneapolis, Minnesota 55408
823-8261
Rep. Bob Anderson

Bausch & Lomb Optical Co.
27 North 4th Street
Minneapolis, Minnesota 55401
335-5195
Rep. George Winikates
335-8788

Becton, Dickinson & Co.
Rutherford, New Jersey
Rep. Herbert S. O'Connor
Lakeview Terrace
Waconia, Minnesota 55387

Bower and Haack Microscope Service
Benjamin Haack, Manager
1826 Como S. E.
Minneapolis, Minnesota 55414
331-5791

Braun Mfg. Co.
Midget Incubators
Box 274
Chatham, New Jersey 07928

Carolina Biological Supply Co.
Burlington, North Carolina 27216
No local representative

Central Scientific Company (Cenco)
Bob Bieser, V. Pres.
1700 Irving Park Road
Chicago, Illinois 60613
Rep. Ed Lang

Chicago Scientific Corp.
Laboratory Apparatus and Chemicals
7319 Vincennes Avenue
Chicago Illinois 60607
Attn.: E.C. Lieber

Corning Glass Works
Laboratory Products Inc.
Corning, New York 14830
Rep. Timothy V. Hartnett
514 Grand Avenue
St. Paul, Minnesota 55102
227-2369

Creative Educational Society
Box 589
Mankato, Minnesota 56001
Rep. Fred E. Wheeler
3609 Aldrich Avenue So.
Minneapolis, Minnesota 55409
822-5664

Denoyer-Geppert Company
5235 Ravenswood Avenue
Chicago, Illinois 60640
Rep. T. H. Kjorlaug
201 Milbert Road
Minneapolis, Minnesota 55426
545-5990

Doerr Glass Company
Vineland, New Jersey 08360
Rep. Richard Wheeler
2086 Iglehart Avenue
St. Paul, Minnesota 55105
645-8746

Eckert Mineral Research, Inc.
110 East Main Street
Florence, Colorado 81226
No local representative

Edison Scott Squire Co., Inc.
New Richmond, Wisconsin 54017
No local representative

Elgeet Optical Company, Inc.
303 Child Street
Rochester, New York 14611
No local representative

Farmer Seed and Nursery Co.
4631 Excelsior Blvd.
Minneapolis, Minnesota 55416
920-1733

Faust Scientific Supply Company
5108 Gordon Avenue
(Biology material only)
Madison, Wisconsin 53716

Foam Plastics, Inc.
17 Southwest Third Street
Osseo, Minnesota 55369
425-4224

General Biological Supply (Turtox)
8200 South Hoyne Avenue
Chicago, Illinois 60620
No local representative

General Science Service Company
Rep. Chester Newby
3450 Yosemite Avenue
P.O. Box 8423
Minneapolis, Minnesota 55426
929-2385

The Industrial & Scientific Instrument Co.
5225 Germantown Avenue
Philadelphia, Pennsylvania 19144
No local representative

Arthur S. LaPine & Co.
6001 South Knox Avenue
Chicago, Illinois 60629

Macalester Scientific Corp.
Joseph Hart
253 Norfolk Street
Cambridge, Massachusetts 02139
No local representative
(New Sales & Services Facilities)
Rep. Thomas F. Shea
215 Burlington Street
Western Springs, Illinois 60558
(312) 246-6070

A.J. Nystrom Company
3333 Elston Avenue
Chicago, Illinois 60618
Rep. Ed Hurley
5209 Mirror Lake Drive
929-4958

Physicians & Hospitals Supply Co.
1400 Harmon Place
Minneapolis, Minnesota 55403
333-5251
Rep. Merlin F. Peterson

Pioneer Plastics, Inc.
8321 Atlantic Blvd.
Jacksonville, Florida 32211

E.H. Sargent & Company
4647 West Foster Avenue
Chicago, Illinois 60630
(312) 777-2700
Rep. Merle T. Nelson
5746 Harriet Avenue
Minneapolis, Minnesota 55419
(612) 823-3301

Schaak Electronics Inc.
3867 Minnehaha Avenue So.
Minneapolis, Minnesota 55406
729-8382

Science Associates
P.O. Box 216
194 Nassau Street
Princeton, New Jersey 08540
No local representative

(Suppliers of Science Equipment and Materials and Their Representatives - 3)

Science Electronics, Inc. (Linco)
195 Massachusetts Avenue
Cambridge, Massachusetts 02139
(Formerly Lincoln Apparatus, LINCO)
(for PSSC physics)
Rep. Terrence McGann (SIGNAL SYSTEMS)
340 East Franklin Avenue
Minneapolis, Minnesota 55404
339-9195

Scientific Products
3846 Washington Avenue North
Minneapolis, Minnesota 55412
529-7735
(Division of American Hospital Supply Corp.)
Rep. Roy Sternard
788-3371
City Desk - Richard Marty

Stansi Scientific Company
1231 North Honore Street
Chicago, Illinois 60622
No local representative

E. G. Steinhilber & Co., Inc.
102 Josslyn Street
Oshkosh, Wisconsin 54901
No local representative

Trans-Mississippi Biological Supply
892 West County Road B
St. Paul, Minnesota 55113
489-5259
Rep. B.L. Hawkins
(afternoons -
646-4843, Station 254)

Viking Safety & Supply Division
2474 Territorial Road (Safety glasses)
St. Paul, Minnesota 55114
646-3744

George T. Walker & Co.
2218 University Avenue S.E.
Minneapolis, Minnesota 55415
333-3343 - City Desk (Ed Sears or
Gordon Danielson)
Rep. Charles L. Howe
6104 11th Avenue South
Minneapolis, Minnesota 55417
869-2348

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Ward's Natural Science Establishment, Inc..
P.O. Box 1712
Rochester, New York 14603
No local representative

W. M. Welch Scientific Company
7300 N. Linder Avenue
Skokie, Illinois 60076
Rep. Chester L. Nightengale
Box 473
Alexandria, Minnesota 56308

Wilkens-Anderson Company
4525 W. Division Street
Chicago, Illinois 60651
Rep. James Ramseth
4525 W. Division Street
Chicago, Illinois 60651

Wright's Mineral Service Inc.
3207 Cedar Avenue
Minneapolis, Minnesota
722-9677 (Anderson's)
Rep. Erdis Wright
9612 Chicago Avenue South
Minneapolis, Minnesota 55420
881-0032